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Compulsory Sewage Purification.

The tendency of late to pass laws compelling communities and industrial companies to purify their sewage before it is discharged into bodies of water has begun to produce the inevitable result in some States. For a good many years Massachusetts has controlled this and other subjects relating to public health through the medium of a highly efficient State Board of Health. Like any other body of men, it has not been infallible, but, on the other hand, it has been admirably conservative and patient in its work for sound sanitation. There are engineers in the Commonwealth

who believe that the Board has occasionally made rulings which imposed needless hardship of one sort or another on the cities with which they were connected, but this journal has yet to learn of a case where this feeling continued long and developed into bitterness. This is a condition which is well worth the careful consideration of the officials in other States intrusted with the approval of sewerage and sewage disposal plans. No State commission will have much power, in fact it will probably not live very long, which antagonizes the representatives of many important communities. In public affairs more is to be won by concessions than by fighting, as a rule, and where a commission is faced with the alternatives of complete failure or success except on a few minor points, the choice of the first alternative indicates a lack of appreciation of public responsibility that is most unfortunate. It is commendable to strive for heaven on earth, but it is foolish to keep people from all good things simply because complete goodness is so very rare.

The selection of the proper method of sewage disposal for a community is a subject on which specialists of the highest standing will often differ considerably. Probably there are several plans, all good, and the decision as to the best depends mainly on forecasting future conditions. No commission can afford to be minutely critical on this account. It is generally admitted that the discharge of small quantities of sewage into lakes and streams from which municipal water supplies are taken is not objectionable if the water is filtered before it is used. Until quite recently it was even held in many quarters that the use of such water without filtration was justifiable. That it is not a serious danger is evident from the fact that very few American cities using surface water supplies have that water filtered before it is distributed. If the danger was as great as some sanitarians have insisted, the typhoid fever rate in most cities would be horribly high, which it is not. On the other hand, experience everywhere shows that it is desirable to filter most surface water supplies, and cities using such water should regard this as a certain necessity within a comparatively short time. This is a condition that bears directly on the subject of sewage disposal, and one which is overlooked by most people in discussing what the State control of sewage disposal can accomplish.

It is commonly believed that complete control of the sewage disposal systems of a State and the rigid enforcement of harsh rules absolutely preventing the discharge of untreated or partly purified sewage into a stream, will render the waters of that stream fit for drinking without purification. This is erroneous. There are some streams with beds so full of filth that they will never run clear enough to serve as sources of water supply, except with the most careful filtration of the water drawn from them. The Schuylkill River, for example, can be materially improved, yet it will never be advisable, no matter how much restriction is placed on the discharge of sewage into it, to use its waters for a municipal supply except after filtration. It is the same with many other streams that might be named, and it is accordingly necessary for a legislature to be extremely careful about putting in the hands of a commission the power to insist on enormous expenditures for the complete purification of sewage. There are few cities in the country which need to completely purify this part of their wastes; in most cases it is probably sufficient at the present time to prevent the sewage from becoming a nuisance to lower riparian communities, and in most of the remaining cases a very moderate degree of purification is all that present conditions demand.

It is an unfortunate fact that a good many people clothed for a short time with official powers of revision and approval or rejection take themselves and their duties too seriously, and

overlook the fact that not only are they liable to removal from office but the legislation on which they depend for their powers is subject to revision at any time. It is particularly desirable when a sanitary commission begins its labors that it should inaugurate a policy that will grow in favor, and it should not proceed to antagonize all the cities of the State. Because the laws give a commission the power to require the complete purification of all sewage before it is discharged into bodies of water, the commission is not obligated to insist that this shall always be done. In some States there is a fair prospect of witnessing the absurd legislation which requires all sewage to be purified before it is emptied into a body of water, and commissions appointed to act under such a law have a most delicate task. Such legislation is as foolish as would be laws requiring sewage to be treated by a single method, and it is highly desirable that no more of it be attempted. It is based on imperfect knowledge of the requirements of public health and can do nothing but harm.

Cross-Tie Production in the United States.

The great importance of the demand for cross-ties is shown by some figures recently published by the U. S. Forest Service. It has been generally recognized that the timber employed annually for this purpose ran to large totals, and the increasing difficulty of securing it in some sections was giving railway officials quite a problem to solve. The figures given out from Washington show that the common belief is an underestimate of the magnitude of the demand, and as these figures cover all but 2.9 per cent. of the total railway mileage in the country, the general facts shown can hardly be questioned. In one respect, it is true, they leave something to be desired, for they give the numbers of ties purchased and not the number used. It is not unlikely that the financial condition of the roads last year was such that more money was spent on the renewals than would be the case during a marked business depression, but even when it is granted that the purchases may be ten per cent. above the average, the significant fact remains that about 91,500,000 ties were bought for steam and electric railways, and the steam lines alone spent \$36,600,000 in round figures, for this single item. Less than one-fifth of these ties were for new track, showing that even in a period when new construction was above the average it was really unimportant in its influence on the tie problem.

It is unfortunate that similar figures for years prior to 1905 were never collected, because they would show the change in the species of tie timber that is taking place. Almost half of the ties bought during 1905 were oak, and it goes without saying that an annual demand for over a billion feet of this timber, about a quarter of the total oak lumber produced, will pretty soon make oak ties too expensive for most roads. The oak tree grows slowly, and unless the railways can conduct forestry enterprises of great extent they must gradually abandon ties of this wood. Something under a quarter of the ties bought in 1905 were pine, averaging 42 cents apiece against 55 cents for oak. About three-fourths of them are probably southern yellow pine and a much larger percentage of them are sawed than is the case with oak. These two timbers supply about five-sevenths of all the ties purchased in 1905, and as they are growing rapidly in value for purposes where a greater sum can profitably be paid than is the case with cross-tie lumber, the lesson taught by the figures does not need prolonged discussion.

After these two timbers, cedar, chestnut, red fir, cypress, tamarack and hemlock follow in the order given. The first two yield excellent tie material, but the supplies are limited. The others are only used locally, as is the case with perhaps twelve or fifteen more species. The increase in

the use of these minor varieties is doubtless due in some degree to the change in the source of ties. It is no longer always possible to obtain an ample supply of ties from land adjacent to the right of way, in fact comparatively little can now be secured in this way. The supplies come more and more from small wood-lots, which are worked over by farmers during the winter, and from the tops and small trees cut in lumbering operations for other grades of timber. Instead of being the major product of the forests it has been forced by its low price into the position of a minor product, in spite of the enormous total quantity of timber used in it.

The figures compiled by the Forest Service show that about 38 per cent. of the ties came from the Southern States and 23 per cent. from the Central States. This is not surprising, because practically all of the great hardwood forests and all the cypress and southern pine forests are in these sections. About nine-tenths of the ties are obtained east of the Rocky Mountains, probably because the cost of transportation prevents Pacific Coast ties from being shipped East at a profit.

The general condition indicated by the data of the Forest Service is one of an approaching shortage in tie material at a fair cost unless steps are taken to increase the life of ties. It is surprising as well as gratifying to learn that nearly ten per cent. of the ties bought in 1905 were given a preservative treatment of some character. Although there has been much discussion of wood preservation, it hardly seemed possible that this discussion had yet resulted in such an excellent showing. It is one of the things that are bound to spread rapidly, like better methods of fastening rails than the destructive spike, and just as soon as the economic advantages of European methods of dealing with cross-ties are more generally recognized by the higher officials of American railways we may expect to see a change in the cross-tie data collected by the Forest Service. The inauguration of such statistical work is to be commended, and it is to be hoped that it will be regularly continued hereafter.

Street Plans.

In the last annual report of Mr. George S. Webster, chief engineer of the Bureau of Surveys of Philadelphia, there is a short but convincing statement of the importance of planning the street systems of a city with regard to the future. He reports that some of the public works in the City of Brotherly Love are made very difficult on account of the narrow roadways, and mention is made particularly of the difficulty that has been experienced in finding room for some of the large mains for the improved water supply. The same trouble has been experienced in the older parts of other cities; in fact, the narrowness of some old streets is such that when lofty buildings have been erected along them, some of the old underground constructions, particularly sewers, have been seriously injured by the disturbance of the earth on abutting private property. The inconvenience of these narrow carriageways and sidewalks in lower New York and in portions of Boston is so evident to the visitor as to elicit the commiseration of those who are not forced to put up with the inconvenience.

While narrow streets prove extremely undesirable in a large city, it is equally true that wide streets are a costly luxury in a small city. The land occupied by them is so great that its maintenance in a presentable condition is an expensive undertaking. Until quite recently, it was customary to lay out a very wide roadway and two very wide sidewalks; the expense of such a wide roadway of macadam was prohibitive, and consequently the surface of the street was gener-

ally a mass of ruts and ridges, while the sidewalks were a few lines of plank bordered on each side with a luxuriant growth of weeds. It was a case of ambition overruling prudence, and its common occurrence in all parts of the country shows that the economics of street planning were little understood anywhere. Between the narrow lanes of the cities of the colonial days and these great avenues of seventy-five years ago lies the middle ground of a rational street system, and a careful study of it has yet to be made. Some day an engineer with abundant leisure and a fondness for the historical features of his work will investigate the subject and produce a monograph worth while, but until all the data are available and the experience of typical cities has been dug out of old records, about all that can be done is to compromise the needs of the present with the possible requirements of the future.

It is an easy matter to ascertain the needs of the present time, and there are good reasons against spending money beyond them except with respect to street width and grades. Pavements and sidewalks are not permanent improvements, and there is not much justice in requiring taxpayers to pave a wide expanse of roadway for a very light traffic or to construct sidewalks of great width for the use of a few people. On the other hand, there are good reasons for securing space enough for a wide carriageway if it should become desirable and for having enough room for wide sidewalks when they are needed. It is too often assumed that such provisions are based only on a hope that the street will become an important business thoroughfare. The fact is that plenty of available street width tends to increase the value of property of every kind. It gives an opportunity for the luxurious streets desired by wealthy people, and in sections where small rentals are paid the additional room for fresh air and for the children means a great deal more than is commonly recognized.

The method of meeting these two conflicting requirements for ordinary streets seems to be pretty well settled by experience in the rapidly growing suburbs of all large cities. It is to construct the macadam carriageway wide enough for the probable needs of ten or fifteen years and to park most of the strip outside the gutters. As the requirements of traffic increase, the roadways can be widened at comparatively little expense and still leave ample room for sidewalks. Most people take enough interest in their homes to keep the grass strips in good condition and are pleased with the relatively low cost of this procedure.

The wide thoroughfares, intended to become main streets as the place develops, are a source of much perplexity to town authorities, and no favorite way of treating them is apparent. In some places settled years ago there are streets over a hundred feet wide, bordered on each side by rows of magnificent trees which arouse admiration whenever seen for the first time. These trees form a troublesome feature of the local street problem, however, for they fix in a measure the improvement that can be made. It will be noticed as a rule that in such cases carriages follow a little strip of road close to each side of the street, and about all that can be done is to improve these strips with good macadam and to reserve the central unused strip for street tracks and parkways. This is done in some places where the broad avenues are new, but about as often there is a broad central roadway, then on each side a parkway with a sidewalk, then a narrow carriageway, and outside of all another sidewalk. Such a street section can be seen in a good many cities, but the reasons for adopting it are difficult to ascertain. There are also a good many variations of these types, due in some cases to local conditions on one side of the road and in other cases to reasons which can-

not be determined from any inspection of the avenues. In most cases in this country these broad avenues with broken surfaces run through sections but sparsely built up and consequently the parking is not in good condition and the result is decidedly unsatisfactory. Probably the streets are unnecessarily wide and their proper maintenance is financially impracticable. A study of them and a discussion of the different types of design fitted for different conditions ought to be made, in order that more heavy losses may not be charged up to lack of information on the subject.

Engineering--Contracting.

Elsewhere in this issue will be found a detailed defense of engineering-contracting companies, prepared by Mr. George A. Damon, managing engineer of the Arnold Co. This is a subject which is just now arousing considerable discussion among engineers and contractors, although very little has appeared in print concerning it. Probably the members of these companies do not know the extent of the interest that is taken in their business. Consulting engineers are insisting that they are violating all the established rules of professional conduct, contractors are claiming that they are undermining the essential supports on which sound construction work must rest, and supply men are complaining that they are simply ruining business by their refusal to buy materials and equipment except at cut rates. Nevertheless more strong companies of this character are being organized right along and the older ones seem to be happy. There is a reason for this new development in engineering lines, and while Mr. Damon states part of it, there is one feature he does not explain, although it is a very important one.

The engineer-constructor is defined in this interesting paper as an organization of specialists, prepared to carry through an enterprise from beginning to end without outside assistance. It designs the work in hand and builds it, thus enabling the owner to deal with a single party. It usually carries on the enterprise on the cost plus a percentage basis, or some modification of it, so that the owner is able at all times to know just what everything is costing, and to cut down or increase the expense of any details; he can also stop the whole agreement if he so desires and turn the plans and unfinished work over to other parties to complete. This is the substance of the main argument. It is manifest that its validity depends mainly on the presence of real specialists in the organization, and this depends in turn on whether enough work can be obtained to warrant such specialists joining a company of this nature. Most men of sufficient experience and business judgment to rank as specialists prefer to be independent, and one of the main advantages of an engineer-constructor company is lost if its department heads are not thoroughly competent men. It is manifest, therefore, that a difficulty with the successful conduct of a business of this nature lies in securing for it the active participation of really good men, so that it will be actually as well as nominally independent of outside assistance. This demands that the executive head of the business must be an unusually competent officer, for he must not only be able to get together and keep happy under one roof a number of men prone to be jealous of each other, but must also be able to secure enough work for them. If this can be done, it must be admitted that the resulting advantage of having all plans for an undertaking prepared in a single office is a decided one, tending to produce good results at a minimum expense.

It is an undeniable fact that these companies buy their supplies and equipment at a somewhat

lower rate than is generally given. This is not so much because they bullyrag manufacturers as for the reason that their clients are generally excellent people with whom to do business, and also because the delivery and installation of machinery is done more economically when there is but one party to satisfy than where there are various technical experts and a string of contractors and sub-contractors to deal with. An engineer-constructor company risks too much itself to become engaged in work with an uncertain financial end, and its business judgment will keep it out of unstable enterprises, providing, of course, its judgment is sound. There are bound to be some companies of this class which will not see the force of this consideration, and their troubles will discredit others in the same line which are conducted on a safe basis. This will happen in every profession and business, however, and does not affect the general argument.

It may be questioned whether any of the claims made above for the engineer-constructor are as strong as one that is not mentioned by Mr. Damon and does not often appear in technical discussions. Along with the assertion that the average business man, who has to direct large affairs, prefers to deal with a single party on each undertaking, must be reckoned the additional fact that the average business man does not like to deal with a professional man more than he has to. What he wants are results; what he too often gets are explanations from the professional man that the contractor is at fault for delays and extras, and protests from the contractor that the professional man does not know his business. After being worried in this way, he often finds that the work has cost far more than he was told it would in the beginning and will not do what he anticipated except at an unexpectedly high figure. That this is a condition which often arises cannot be denied, and the reason for it is that the work is in the hands of too many independent and semi-independent people. It does not need to arise and probably will not if the owner is lucky enough to get the right professional men at the outset and the right contractors. But just so long as human nature remains as it is, there will be good professional men and good contractors who cannot get along together, while all hope of peace is gone as soon as a poor man gets into the combination.

There is another closely allied aspect of the subject that must also be taken into consideration. The engineer-constructor company is primarily a business organization. Its success depends on accomplishing what the owner desires as promptly and economically as possible. The engineering work is merely one branch of its business. In this branch the aim is to plan so that the owner will secure what he is after. It often happens that a heavy investment is kept idle waiting for equipment or supplies of some character. The business sense of the head of such an engineer-constructor company shows him that the interest charges and loss of profits caused by this delay are running up at a rapid rate, and he goes to the owner and explains that by using a poorer design or poorer equipment than the plans called for he can save money. If this suggestion is followed, the chances are that this feature of the construction will be derided as wretched by those who see it for the first time and know nothing about the reasons for its presence. A professional engineer could hardly afford to risk his reputation by taking such a course, even if his business training enabled him to see its importance, but one of these companies, which have nothing to gain or lose from the criticism of professional men, will have no hesitation whatever about giving such advice.

These comments on Mr. Damon's paper are made because it is necessary to recognize that engineer-constructor companies have come to

stay, at least for a considerable time, in some lines of engineering and architectural work. Their success is primarily due to the fact that they relieve the owner of a lot of annoyance. What they will develop into remains to be seen. They will never supplant the independent professional man and the general contractor, for their field lies only in very large operations. They are essentially an accompaniment of the general tendency to concentrate large business affairs of all kinds. Their rise and the reasons for it might be discussed at great length, but the main facts as they are seen by this journal are substantially those stated.

The First Contract for the Catskill Aqueduct.

The plans and specifications for the construction of portions of the Peekskill Division of the proposed Catskill aqueduct, aggregating about 11 miles in length, forming part of the works for providing an additional water supply for New York, have been already noticed in The Engineering Record of Nov. 10 and the work covered by them described. The bids for this aqueduct construction are to be opened by the Board of Water Supply on Dec. 4, and the award of this contract will mark the beginning of the greatest public water-works yet undertaken. This in itself is sufficient to give a marked character to the award of this contract, but in other aspects the beginning of this great work is worthy of comment.

The portions of the aqueduct contemplated to be built at first are located largely in the Croton water-shed between a point nearly east of Peekskill, and another close to and east of Cold Spring. It is seen, therefore, that this part of the aqueduct lies nearly adjacent to the Hudson River crossing which, it is understood, will be at the highlands immediately north of West Point. There are a number of obvious reasons why this part of the work is first undertaken. It is to some extent the easiest to put under contract in a comparatively short time. The aqueduct between the limits named above is mostly cut-and-cover work, although there is considerable of the line in tunnel. The features of such work permitted an early completion of plans and specifications and thus enabled it to be undertaken in a much less period of time than other parts of this great undertaking, in connection with which there are engineering problems of extraordinary difficulty and unusual magnitude. Furthermore it is probably recognized by the Board of Water Supply that the city may suffer conditions at least approaching a water famine before relief from the Catskill water-sheds can be attained. Under such conditions it will be imperative for the city to secure water temporarily from any source which it is feasible to reach. It is not impossible, if, indeed, it is not highly probable, that it may be pressing necessary to secure the water of Peekskill Creek for at least a short period of time to relieve an exigency of this kind. The construction of the southern portions of the aqueduct covered by this contract will enable the waters of this stream to be turned into the aqueduct by pumping if necessary and thus reinforce the Croton supply. This possible source of relief has already been thoroughly discussed, and it is no more than prudent to provide for using it to its full extent in case of need. While the flow of Peekskill Creek is not of great volume it is sufficient to make it of no small value under conditions of drouth which may easily occur.

The construction of a cut-and-cover aqueduct affording a channel for the flow of water 17½ ft. wide and 17 ft. high is out of the ordinary. While it might at first seem that the merits of reinforced concrete would best satisfy the requirements of such work, it is probably most pru-

dent to give this great concrete channel such dimensions that it shall possess all the needed strength and stability for its duties without steel reinforcement. At the same time use is made of steel where it may be of real benefit to the work, as in the case of syphons and other special structures.

Probably there is no part of the entire specifications for this work which shows more clearly the advance in concrete fabrication than that relating to the proportions of cement, sand and broken stone or gravel. The value of the finer portions of the product of the crusher as sand is recognized and its use is fully contemplated. It is to be pointedly observed that no rigid proportions of mixture are prescribed. The nearest approach to exact proportions is found in a section where it is stated that generally the "concrete will be mixed approximately in the proportions of one volume of cement to eight volumes of sand or screenings, and gravel or crushed stone, the sand or screenings and the ballast being measured separately." It is clearly the purpose to pursue the rational procedure of determining the mixture that will make the most nearly impermeable concrete with economical proportions, providing sufficient cement to fill all the voids and perhaps a little more of the remaining aggregate. The specifications covering rock tunnel work are equally reasonable with those for concrete. A limiting line is carefully defined and prescribed within which excavated material will be paid for and outside of which the contractor is essentially advised that he must excavate at his own cost. In other words, the limit of the paying excavation is made perfectly clear to him, so that he may control his work in such a way as to reduce to a minimum his non-paying work.

THE INJURY TO NIAGARA FALLS by the diversion of water for power purposes was the subject of a hearing given on Nov. 26 by Secretary Taft, in the course of which he made a number of remarks that were decidedly tart. Early in the hearing statements were made criticising Capt. Kutz, the engineer who investigated the conditions at the Falls for the War Department, but the Secretary promptly stopped such talk by stating that the investigation was made exactly in accordance with the Department's orders. The Secretary was next told that he should pay proper attention to the flood of postal-card protests which had been turned his way by the American Civic Association and other bodies of like nature, but he replied that while a great number of these cards had been received, including some from his mother and aunt, they did not help him in determining his duty under the law. It was asserted that Capt. Kutz gave newspaper interviews in which he went into the economics of the subject and of the profits which the power companies had a right to expect from their investments. This led Mr. Taft to remark somewhat warmly that the character of the members of the Corps of Engineers was too high for them to be the subject of such criticism; he did not have time to consider views of newspaper interviews, but he wanted the subject discussed in an atmosphere of justice, not one of hysteria or corporate greed. An attempt was also made to explain what "the people" thought was the Secretary's duty under the law passed for the preservation of the scenic grandeur of the Falls, but Mr. Taft cut that short with the statement that he could not see what popular sentiment had to do with the construction of a statute that had been passed. All in all, the day must have been an unhappy one for those who have been having spasms about the future of the Falls, and their discomfort will not draw much sympathy from anybody who has taken the trouble to ascertain just what the present laws cover.



General View of the Quebec Bridge as it will Appear when Complete.

THE ANCHOR ARMS OF THE QUEBEC BRIDGE.

NOTES ON THE GENERAL DESIGN OF THE ARM COMPLETED DURING THE SUMMER.

The \$4,000,000 bridge across the St. Lawrence River, near Quebec, is 2,800 ft. long between centers of anchorages and will have a total width of 82 ft., including the cantilever sidewalks. It is designed to carry two railroad tracks, two highways and two electric car tracks on a single deck about 200 ft. high above extreme low water. The 1,800-ft. cantilever span across the channel is flanked by two 500-ft. anchor arm spans, each of which weighs about 12,500,000 lb. exclusive of about 1,400,000 lb. for its portion of the floor system, as described in *The Engineering Record* of March 4, and Sept. 16, 1905.

The erection of the south anchor arm on fixed falsework has been completed this summer, as described in several articles in this journal, and it is the purpose of this article to illustrate important features of the design. Some of the details are entirely novel and all are of interest on account of their dimensions, many of them unprecedented, and the great care with which they have been perfected and verified by specialists.

Work on them has been in almost constant progress for about four years and they have been made to conform to a rigid analysis of conditions, to elaborate computations and to the requirements of the highest grade of shop work. They have also been adapted to the greatest safety, facility and rapidity of field erection, and have been proportioned to secure the greatest rigidity in the structure consistent with economical weight. Indeterminate stresses have been avoided and members are proportioned strictly according to the actual service which they will perform under assumed maximum conditions. The great capacity and unprecedented dimensions of the bridge have therefore involved such high stresses in large members that the latter have exceeded all previous limits for shop-built pieces; it has been necessary to provide unusual sections, some of them very massive and some of them limited only by the restrictions of transportation and by the maxima of commercial manufacture of steel plates and sections employed.

The main trusses are in vertical planes 67 ft. apart, the top and bottom chords are segments of parabolic curves, intended to combine a graceful outline with theoretical requirements for depth. They carry the single-deck floor on a 1 per cent. grade up from the level of the bottom chord at the anchorage to a point 120 ft. above the top of the main pier. The depth of the trusses increases from about 97 ft. on centers at the anchorage to 315 ft. at the main pier. They are divided as shown by the general elevation into five 100-ft. main panels, or ten 50-ft. sub-panels, each main panel being subdivided in two 50-ft. panels. Alternate sub-panels have horizontal struts and counterdiagonal struts stiffening the main web members. An important feature of the design is the use of separate pins at each main panel point top and bottom for the connections of chords and tension diagonals with the vertical posts. This arrangement greatly reduces the bending moments and consequently reduces the sizes of the pins, and facilitates assembling the members during field erection.

The trusses have lateral bracing in the planes of the top and bottom chords and in the floor system. The top lateral system is composed of transverse struts and X-braces in every panel, all riveted between horizontal connection plates at the tops of the vertical posts. The struts have rectangular cross-sections made with four angles latticed on all sides. The X-braces have I-shaped cross-sections, made with two pairs of angles back to back, latticed, one brace being cut to clear the other at the intersection, where both are field-riveted between top and bottom flange cover plates. The lower lateral system consists of transverse struts and X-braces in each panel; the former are pairs of built channels with vertical webs, flanges turned in and latticed; the latter have each flange built of two angles and one coverplate, 26 in. wide, the two flanges connected by latticing in two vertical planes, the connections corresponding with those of the top laterals. The floor system consists of floorbeams at panel points, supporting twelve lines of web-connected stringers, all braced together with zigzag angles in the planes of their top and bottom flanges.

Transverse swaybracing is provided in the planes of all the vertical posts and is arranged in one or two panels above the roadway and one or two panels below it, as shown by the cross-sections. The horizontal struts and X-braces all have rectangular cross-sections built of four angles latticed on all sides; they are field-riveted at their intersections and at the ends between wide and heavy jaw plates, which also serve as splice plates for the vertical posts and have their edges curved to give a pleasing effect to the structure. Those above the roadway have uniform cross-sections made of four 4x4-in. angles. Below the roadway the trussed floorbeams form part of the X-brace members in the upper panels and those in the lower panels have I-shaped cross-sections made with two pairs of angles back to back, latticed.

The maximum stress in the top laterals is 341,000 lb. for which a net section of 17.2 sq. in. is required, consisting of four 6x3½-in. 16½-lb. angles. In the bottom chord laterals the maximum diagonal stress is 977,000 lb., requiring a sectional area of 66 sq. in., which is provided by four 6x4-in. 26-lb. angles, four 6x7-16-in. flats and two 25x½-in. cover plates.

All of the chord members are made in single panel lengths varying from 50 ft. on centers at the anchorage to over 60 ft. at the pier, where they are most steeply inclined. The top chord proper is composed entirely of 15-in. eye-bars from 1½ to 21-16 in. in thickness. The maximum stress from live and dead load and wind pressure is 15,755,000 lb., for which a total cross-section of 711 sq. in. is provided. The bottom chord has a rectangular cross-section about 4½ ft. deep and 5½ ft. wide over all, made of four built channels having their flanges latticed with angle bars. The maximum live and dead load stress plus wind stress is 19,150,000 lb., for which a sectional area of 842 sq. in. is provided. The direction of the bottom chord changes at the pin centers; to facilitate erection a short section of the adjacent chord is shop riveted to each fol-

lowing chord piece to provide a field splice clear of the panel point beyond it on the river side.

All vertical posts except the main posts over the pier are made of two built channels in the planes of the trusses with their flanges latticed, and are field spliced at one or two points. The sub-posts, intersecting the tension diagonals, are provided with pairs of extended flange plates to receive the latter members on separate pins at each side of the vertical post. The maximum combined dead, live and wind stress is 2,244,000 lb., for which there is a cross-section of 110 sq. in. provided by four 6x6x31.8-lb. angles and four 32x9-16-in. web plates. The total stress in the main vertical post is 10,132,000 lb., with a corresponding net section of 422 sq. in., which, in order to provide for bending between the floorbeam and the portal, is increased to 469 sq. in., and is made up of four built I-beams having 48-in. webs, 8x6-in. flange angles and 7x¾-in. inside flange reinforcement plates.

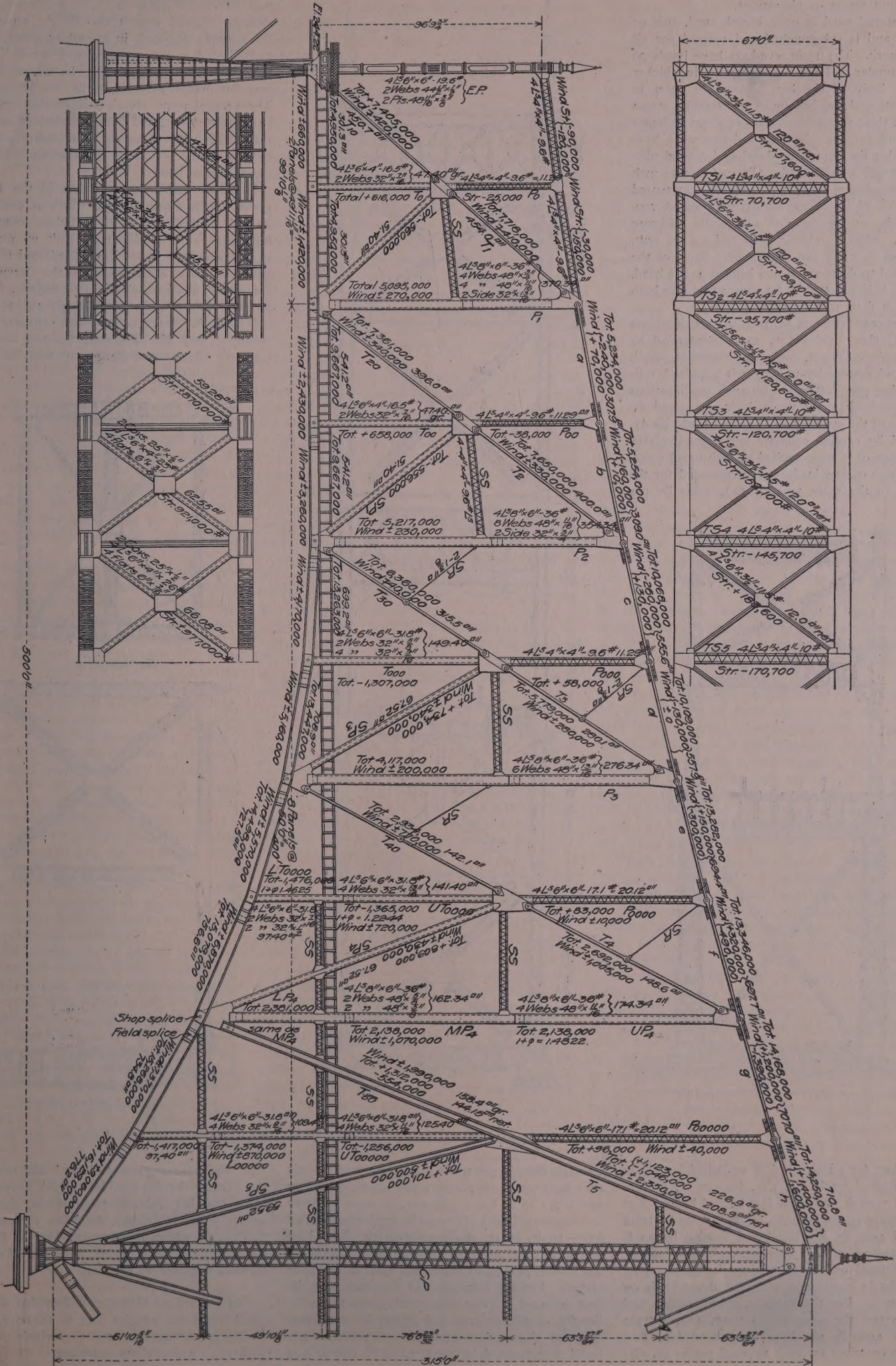
The tension diagonals are made of two lengths of 15-in. eye-bars extending together across two panels and connected, as already stated, to separate pins on opposite sides of the intersecting vertical posts. The maximum total stress is 8,128,000 lb., for which a cross-section of 424 sq. in. is provided in the end diagonal, connecting the top chord proper with the vertical anchorage bars and the bottom chord. The diagonal nearest the main pier is a compression member calculated for a maximum stress of 1,312,000 lb. in compression or 554,000 lb. in tension plus a wind stress of 1,990,000 lb. in either tension or compression. It requires a net cross-section of 144 sq. in., which is made of four 6x6x31.8-lb. angles and four 44x11-16-in. web plates. The short vertical and horizontal struts in alternate panels and the sub-vertical posts reaching from the intersections of the vertical and diagonal members to the top chords to support the latter are made of four angles latticed on four sides and have riveted connections except at the top chord, where they engage the main pins. All of the chord pins, except those at the top and bottom of the main vertical post, are 12 in. in diameter and have maximum lengths of over 10 ft.

In order to secure a more pleasing appearance in side elevation, the line of the top chord is produced, from the top of the end inclined tie to the center of the anchorage pier, by means of false members which intersect an ornamental portal. All of these members are built of light angles, latticed, since they do not carry any dead or live load stress.

The dead load of the bridge is so great that the cantilever will always produce an upward resultant at the shore end of the anchor truss; the vertical anchorage bars there will always be under tension, varying with the live load; and the anchor piers will not receive any weight from the bridge, all of it being concentrated on the pedestals on the main piers. There will, however, be a heavy wind stress transmitted to the anchor piers that will have a considerable vertical resultant. This stress is delivered by the lateral systems to the end floorbeams and thence is transferred through the tower-like vertical members to the top of the piers, where it is taken by the anchor eye-bars and distributed through the pier masonry.

The main chord pins are fitted with a clearance of 3-64 in. and 1-16 in. clearance is allowed for each eye-bar in packing. All the riveted splices and main connections have field rivet holes drilled to cast iron templates and all splice plates are shop fitted and matchmarked. No temperature adjustments are provided in the bridge, except at the expansion joints between the center span and the ends of the cantilever arms. Great care has been taken in checking the drawings and inspecting the shop work; this has resulted in such accuracy that the south anchor arm already erected

PRINCIPAL MAXIMUM STRESSES AND MATERIALS FOR ANCHOR ARM TRUSSES OF THE QUEBEC BRIDGE.



has been assembled in the field without difficulty and without fitting or alterations.

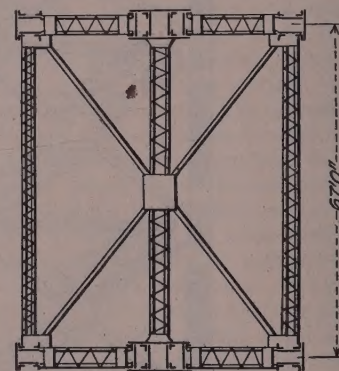
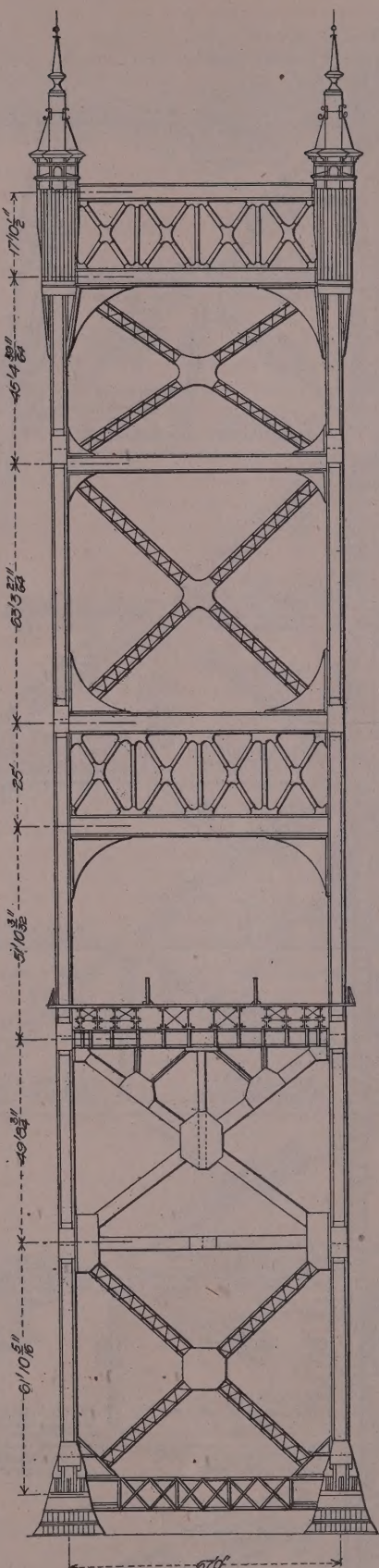
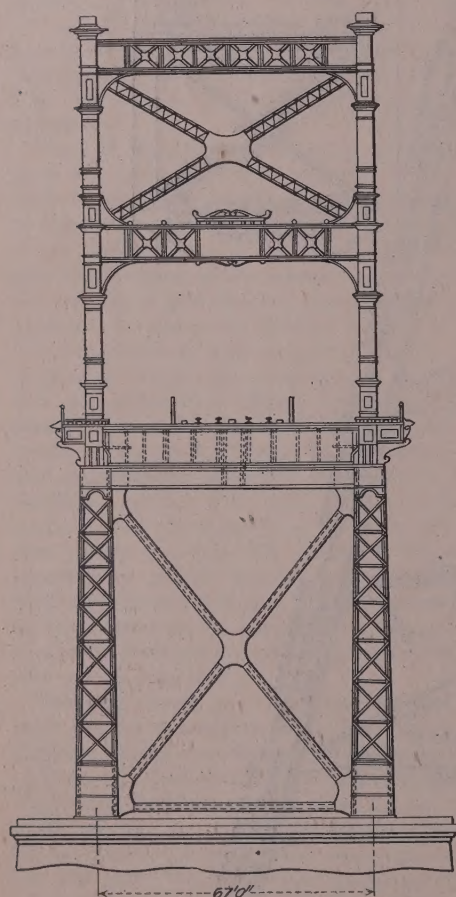
All material used is open hearth steel, soft or medium, and is sub-punched and reamed for all riveted work. The 15-in. eye-bars have heads 36 in. in diameter and not more than $\frac{1}{8}$ in. thicker than the body of the bar. They are upset in three heats and finished under a 12,000-lb. steam hammer; their annealing is done in about 12 hours in a wood furnace. Several full-size tests have been made; the bars have developed a total ultimate strength of about 58,000 lb. per square inch and an elongation of 20 per cent. in a measured distance of 18 ft. These results correspond very well with an average of 66,000 lb. ultimate strength, 36,000 lb. elastic limit and 25 per cent. elongation in small test specimens. None of the bars tested to destruction was broken in the head, and it is believed that great uniformity has been secured in their manufacture.

The superstructure is built on the specifications of the Quebec Bridge Co., as recommended by Mr. Theodore Cooper, consulting engineer, which correspond essentially to Cooper's standard railway bridge specifications, with such modifications as are justified by the unusual character and dimensions of the structure. The dead load was determined by careful estimate and the calculated proportions of it were applied at each panel point. Three cases of live loading were assumed for the stresses in the main trusses, (a), 3,000 lb. per

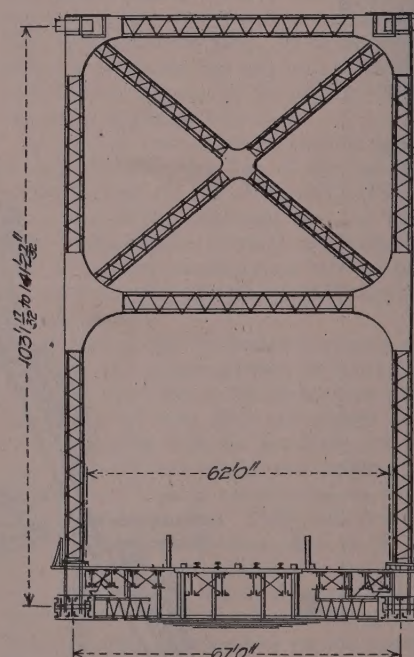
assumed at 500 lb. and that resisted by the bottom laterals at 1,000 lb. The maximum tensile stresses allowed were 17,000 lb. per square inch for I-beams, 20,000 lb. in secondary members, and as indicated in the accompanying stress diagram for the main truss members. The maximum pressure on masonry is 78,000 lb. per square foot. The vertical posts are shop-riveted in lengths of from 45 to 77 ft., and field connections are made with main pins up to 24 in. diameter and with 500,000 $\frac{7}{8}$ -in. and 1-in. field-driven rivets and 10,000 turned bolts.

It is interesting to note that in the 1,710-ft. spans of the Forth bridge, which is entirely of riveted construction with tubular compression members 12 ft. in diameter, built up piecemeal in position, there is $9\frac{1}{2}$ lb. of dead load for every pound of live load, while in this longer pin-connected span with shop-built members, the proportion of dead to live load is only $4\frac{1}{4}$:1.

Mr. E. A. Hoare is the chief engineer of the structure, and Mr. Theodore Cooper, consulting engineer. Mr. Bernt Berger, principal assistant.



SECTION A-A



Transverse Elevations of Portal, Main Tower Bent and Intermediate Bents.

lineal foot for a train load of unlimited length on each railroad track; or, (b), for 900 ft., a train load of 3,300 lb. per lineal foot headed by two E 33 locomotives on each track; or, (c), a 550-ft. train load of 4,000 lb. per lineal foot headed by an E 40 locomotive on each railroad track. No loading was assumed on the electric track, roadways or sidewalks in connection with the above loads on the trusses. For the hangers, sub-diagonals and floor system the assumptions were, (a), a train load of 4,000 lb. per lineal foot headed by two E 40 locomotives on each railroad track; or, (b)

on each electric car track a train load of electric cars each 30 ft. long and weighing 56,000 lb. on two axles 10 ft. apart; or, (c), on each roadway a concentrated load of 24,000 lb. supported on two axles 10 ft. apart. In computing the dead load per lineal foot, 2,500 lb. was assumed throughout for lumber and 3,700 lb. for the steel in the floor system. For the remainder of the steel, 7,800 lb. was assumed for the suspended span, 18,510 lb. for the cantilever arm and 17,880 lb. per lineal foot for the anchor arm. Wind pressure per lineal foot resisted by the top lateral system was

The contractor for the steel work and erection is the Phoenix Bridge Co., Mr. David Reeves, president, and Mr. John Sterling Deans, chief engineer; Mr. P. I. Szlapka, designing engineer; Mr. C. Scheidl, assistant engineer; Mr. A. B. Milliken, superintendent of erection, and Mr. G. A. Tretter, engineer of erection.

THE LAST TOLL GATE in Philadelphia was abolished last year, without cost to the city, by the Philadelphia Rapid Transit Co., which controlled it through a subsidiary company.

The Cost of Clearing and Grubbing a Reservoir Site.

A paper read before the American Society of Municipal Improvements by Julian Griggs, Consulting Engineer, Columbus, Ohio.

In this paper it will be the purpose of the writer to give with some detail the cost of clearing and grubbing the site of the reservoir formed by the construction of the Scioto river storage dam for the municipal water supply for the city of Columbus, Ohio. (See Eng. Record of Sept. 9, 1905.)

The work to be described was but a small portion of the total expenditure of about \$700,000 by the city for the dam and works appurtenant thereto, but the failure of the writer, after a somewhat extended search of engineering literature, to find descriptions of this portion of similar undertakings has led to the hope that a paper on the cost of clearing and grubbing a reservoir site will prove a welcome, though, slight, contribution to the subject of water supply engineering.

Cases of complete soil removed, as in the Wachusett reservoir for the Boston Metropolitan Water System, are not unknown. Perhaps, however, it has never covered so large an area and been done with quite the degree of thoroughness which there obtained, but wherever done it is for the engineer mainly a question of estimating the cost of excavating and hauling a given quantity of earth, while the clearing and grubbing become a secondary matter, as tending only to increase slightly the cost per cubic yard for excavating and removing the earth to a point outside of the reservoir.

In the Columbus case the usual conditions were reversed, for the reason that the Scioto river is normally a muddy western silt-bearing stream, with a drainage area of 1,032 square miles above the dam and a flood discharge approximating a maximum of 50,000 cu. ft. per second. The relation of reservoir capacity to maximum flood flow is such that the reservoir at maximum flood flow would fill and empty twenty times in twenty-four hours. It is therefore expected that silt in material amounts will be deposited in the reservoir at every considerable rise of the river, and under these conditions it was not deemed necessary to remove any of the surface soil except to a very limited extent around former human habitations within the submerged area, but responsive to the requirements of the Ohio State Board of Health, all vegetable growths were cut down even with the ground, being then gathered into heaps and burned, while the stumps and roots of all trees and shrubs one inch or more in diameter were grubbed to a depth of one foot below the surface and similarly gathered and burned.

The reservoir is unique in its way by being unusually long, 5.8 miles, for its width, which varies between 200 and 820 ft., and averages only 504 ft. at the water surface with reservoir full. The river in ancient times wore a gorge in the limestone rock of the Upper Helderberg formation, some 90 ft. below the general level, for a width of from 600 to 800 ft., and in more recent time has filled it in again with rich alluvial deposits to a depth of about 18 ft., through which the present stream, with a descent of 5 or 6 ft. per mile, has cut its slightly meandering channel to 12 ft. in depth and about 200 ft. in width.

In places on either side of the gorge, vertical bluffs 20 to 30 ft. high for perhaps a total length within the reservoir limits of two miles still remain, but generally speaking, the rocks forming the sides of the gorge have crumbled and now appear as steeply sloping hillsides, too rugged for cultivation and for the most part covered with trees and shrubs.

From the above description it will be seen that the reservoir formed by the dam, which has a height of 33 ft. from its apron to its rollway, will fill the gorge at its lower or south end, 720 ft. in width, and only the present river channel, 200 ft.

in width at its upper or northern end. The greatest depth of water in the reservoir is 35 ft. and the mean depth is 14 ft., or 40 per cent. of the maximum. The area of the river at ordinary low water within the reservoir was 125.7 acres, while the water surface of the reservoir at the elevation of the rollway is 351 acres.

A portion of the bottom land for an aggregate area of about 36 acres had been cultivated before it was purchased by the city, but the remainder was thickly covered with a growth of trees and shrubs common to the forests or groves of this locality, and consisted mainly of elm, oak, beech, hickory, maple, buckeye, locust and sycamore, the latter especially growing to large proportions, some of them being 5 ft. in diameter. The shrubs were mostly osage orange, willow and pawpaw and smaller growths of the trees above mentioned. The bottom lands were very fertile, and everywhere, in addition to the trees, supported a rank growth of weeds, among which horse cane (*Ambrosia trifida*) predominated, growing to a height of 8 to 13 ft.

The area to be cleared and grubbed consisted then of two strips of land, one on each side of the river, together with a number of densely wooded islands, aggregating a total of 255.6 acres, 5.2 acres being below the site of the dam, cleared but not grubbed. The outside boundary of the clearing was contour 75 ft., which was 2 ft. above the crest of the rollway of the dam.

The base of levels was city datum on an assumed plane 100 ft. below the water table of the Ohio state capitol.

The dam, and the beginning or south end of the reservoir, is $7\frac{1}{2}$ miles northwest from the center of the city and is now reached by trolley cars with an hourly service.

Bids for the grubbing and clearing were received by the Board of Public Service on May 11, 1904, and varied from \$70 to \$155 per acre, on an estimated area of 20 acres, as shown more specifically in the following table, the totals ranging from \$18,900 to \$41,850:

Name of Bidder.	Rate per Acre.	Total Bid.
Hoover & Kinnear.....	\$ 70.00	\$18,900.00
John H. Clutter.....	149.50	40,365.00
Fisher & Knight.....	155.00	41,850.00

The proposal of Messrs. Hoover & Kinnear, of Columbus, Ohio, was accepted and a contract with them was executed June 6. Work was begun on June 14, 1904, and carried on continuously until completed, April 5, 1905.

The method adopted by the contractors in doing their work was divided into three and at times four operations.

First, a gang called the "trimming gang," consisting of from four to twenty laborers, equipped with axes and grubbing hoes, under the direction of a foreman, trimmed the limbs from the larger trees as high as they could reach, cut off the smaller trees about 2 ft. above the ground, grubbed out the brush and roots and gathered into piles everything that could be burned.

Second, the trimming gang was followed by a "pulling gang," composed of from six to twelve laborers, a team of horses and a stump puller. Their work was to pull up the trees and stumps. Some of the time the same gang and at other times a third gang (third operation) cut the trees and stumps into pieces that could be readily handled, grubbed out the exposed roots and piled the whole for burning, excepting such portion of trees as were saved for saw logs.

When the work began it was thought necessary to partly season and dry the brush and wood by several weeks exposure before burning, but during the winter it was found practicable to burn everything as soon as it was cut and piled.

The stump puller used was of the type known as the "Hawkeye stump puller," and consisted of a vertical iron windlass, operated by a team of horses. The bed to which the end of the spindle of the drum was secured, was formed of two

pieces of oak timber each 10 in. by 10 in. by 16 ft. in length, framed into a cross with equal arms. The drum was 13 in. in diameter and 2 ft. in height. The spindle above the top of the drum was secured by four legs made of iron pipe, inclined outward at an angle of about 45 deg. At the lower ends, the legs were tied together with an iron strap to prevent spreading, and each was fastened to an arm of the timber bed. To the end of the spindle projecting above the legs, was secured one end of an 8x8-in. oak timber; to the other end was hitched a pair of horses, making a sweep of 20 ft. radius. Dragging from this sweep, directly back of the team, was a stiff stick, the end upon the ground shod with an iron point, the purpose being to hold the strain made by the sweep when the horses were standing or when taken away. With each machine there were two pieces of $\frac{7}{8}$ -in. wire cable about 100 ft. in length, hooks, grips, blocks, snatch cables and so forth. Four of these machines were in use by the contractors.

In operation the timber bed was buried in the ground, and to make it secure iron pins were driven into the ground against the sides of the timbers, or the timbers were loaded with stone. The snatch cable was usually fastened around the tree to be pulled from 10 to 20 ft. above the ground. The cable was usually passed through a snatch block fastened to a tree near the stump puller so as to bring it into a horizontal position as it was wound upon the drum. If the tree was too firmly rooted to be moved when the strain was applied, sometimes a part of the roots were cut, but usually it was the practice to explode a charge of dynamite among the roots without releasing the strain from the stump puller. Stumps, of which there were large numbers, were harder to pull than the trees and most of them had to be broken up with dynamite and taken out in pieces. Many of the trees had roots at a considerable distance below the surface of the ground, probably due to the gradual accumulation of earth above them since the trees began to grow. Large quantities of dynamite were used. It is said that sixty sticks were exploded in removing one stump. After the trees had been pulled and burned the ground was all gone over during the months of March and April, all loose pieces of wood were picked up, any grubbing previously overlooked was done and the grass and weeds burned.

The common harrow was found to be the best tool for breaking down and gathering the weeds. It is estimated that 3,000 saw logs were sold by the contractors at \$2.50 per 1,000 ft. board measure, and there would have been many more if the trees had not been shattered by exploding dynamite.

The accompanying table of costs is derived from the inspector's daily reports, and is believed to be fairly accurate. It shows a total cost of \$40,766.75. Common labor was paid \$1.50 per day of ten hours and is the largest item of cost, being 53.3 per cent. of the total. The next largest item is dynamite, 19.1 per cent., followed by foremen, 8.2 per cent., and horses 8.1 per cent., machinery 4.4 per cent., accounting for all but a remainder of 6.9, which is divided among superintendent, dynamite men, time keepers, blacksmith and carpenter. The cost per acre, therefore, for the work done was \$159.50. The final estimate given May 17, 1905, was for 255.6 acres at \$70 = \$17,892.

In addition to the above there was paid to the contractors \$1,685.10 for doing work outside of the contract, the following amounts being cost to contractors with 15 per cent. added for use of tools and profits: Building guard fences along public highways at dangerous places, \$230.48; removing trees and stumps from the river, \$283.75; clearing the city's land above contour 75 ft., \$1,157.51; miscellaneous work, \$13.36; total, \$1,685.10.

The season was unusually favorable for the prosecution of the work as there were no delays and very little additional expense was incurred by reason of high water.

COST OF CLEARING AND GRUBBING.

Item.	Days.	Rate.	Total.	Per cent. of cost.
Superintendent	255	\$4.16 $\frac{1}{2}$	\$1,062.50	2.6
Timekeepers	255	1.75	446.00	1.1
Foreman	1,030	2.50	3,325.00	8.2
Foreman	205	2.00	410.00	1.0
Carpenter	54	2.00	108.00	.3
Dynamite men	435	1.75	761.25	1.9
Laborers	14,491	1.50	21,736.50	53.3
Single horse	222	1.50	333.00	.8
Two-horse team	847	3.50	2,964.50	7.3
Dynamite, lbs.	68,000	.11 $\frac{1}{2}$	7,820.00	19.1
Machinery and repairs.			1,800.00	4.4
Total			\$40,766.75	100.0

Cost per acre, \$159.50.

The foregoing table indicates that the contractors lost a comparatively large sum of money in the execution of their contract, but they never showed any disposition to slight the work or endeavored in any way to diminish to their advantage the amount thereof, neither did they permit the work to drag along, as not infrequently happens under such conditions, but prosecuted it with energy and completed the same within the time limits of their contract obligation, for which honest endeavor they are entitled to and should receive great credit.

Prior to the beginning of the work by the contractors a line of levels was run on each side of the river and stakes set to indicate on the ground the position of contour 75 ft. These stakes were set as often as there was a change in the direction of the contour and were from 50 to 400 ft. apart. As an aid to finding them again they were numbered consecutively from the dam. To check the work the two lines of levels were connected at intervals of about a mile.

After the land had been cleared, survey lines were run one on each side of the valley near contour 5 ft., and the contour stakes previously placed were located by right and left measurements. Survey lines were also run on each side of the river, from which the shore line of the stream was similarly located, and to check the work all of the survey lines were tied together at intervals of about a mile. Contour 73 ft. was also run and a careful observation made to be sure that no grubbing had been omitted below that elevation. All survey lines were then platted and the areas having been computed by latitudes and departures were checked by planimeter measurement on the plats, which were made to a scale of one inch equal to one hundred feet.

In May, 1905, the site of the reservoir was practically cleared of all vegetation and ready to be filled, which, by the requirement of Contract No. 1 for the dam was to have begun by the middle of that month. The work on Contract No. 1 had not been prosecuted at the rate stipulated in the specifications and was further delayed during the summer, so that by the middle of August the whole reservoir site was covered by a luxuriant growth of weeds, some of which measured 13 ft. in height, and it became necessary to remove them before the reservoir could be filled.

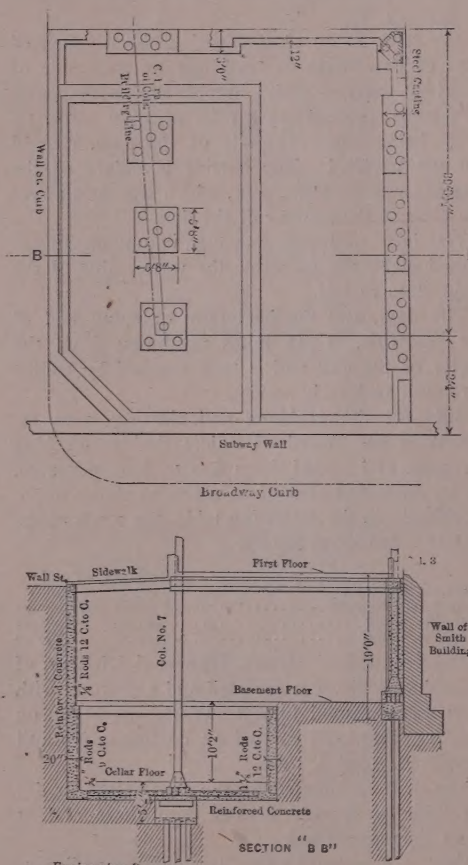
An unsuccessful effort had been made the previous season to burn the dead weeds as they stood upon the ground. Neither would they burn when broken down. The city therefore engaged a foreman with a gang of seven Italian laborers to cut the weeds and after they had sun dried, to gather them into piles and burn them. This work began Aug. 21, 1905, and was continued until water was running over the completed crest of the dam on Dec. 6. Where possible a horse rake was used in gathering the weeds, but where the surface could not be raked, manure forks were used for this purpose.

Shortly prior to Dec. 6 a day was fixed for dedicating the dam and it was then determined to fill the reservoir as speedily as possible. A large gang of extra men with tents and supplies were sent to the reservoir to rapidly complete the weed cutting and cleaning then being prosecuted

by the city foreman and the small gang. The cost to the city of the work so done between Aug. 21 and Dec. 6, 1905, was \$1,969 divided into labor, tools and supplies as shown in the table following:

Item.	Labor.	Supplies.	Total.
Small gang	\$1,210.13	\$43.50	\$1,253.63
Large gang	428.78	286.66	715.44
Total	\$1,638.91	\$330.16	\$1,969.07

It will be seen then for clearing and grubbing of a reservoir site under the conditions which obtained in the work herein described and neglecting the general expense of the contractors, the cost with common labor at 15 cents per hour may be reckoned at \$159.50 per acre, to which there may be added for extra work required a further cost of \$6.73 per acre. And if the reservoir is allowed to grow up with weeds and needs to be again cleaned the added cost will be \$7.86 per acre, or a total for all work done of \$174.09 per acre for the area covered, in which is included none of the cost of engineering and inspection.



were such as to make clear the wisdom of eliminating such girders at the expense of increased work in another direction.

Sectional piles were adopted; these had been designed by the contractor with special regard to compactness, facility in sinking and maximum strength combined with minimum diameter. They consist of cylindrical steel tubes containing vertical steel compression bars and are proportioned for loads of 6,000 lb. per sq. ft. of metal. The concrete filling secures the bars in position and is loaded to 500 lb. per sq. in., thus making all parts of the pile efficient and proportioning it for very much larger loads than can be carried on wooden or concrete piles. At the same time a pile is secured which can be sunk without endangering nearby structures, and in situations where a pile-driver derrick cannot be employed.

The small diameter of the piles enabled them to be grouped as shown in the foundation plan in double staggered rows 18 in. apart on centers and so close to the lot lines that the grillages they support could be made symmetrical with the wall columns and thus avoid the expense and obstruction of distributing girders, so often necessary for wall columns. Care was taken to arrange the piles for the four wall column piers so that they should be equally loaded. The heads of the piles are enclosed in the lower parts of the reinforced concrete piers, over which the column loads are distributed by single and double tiers of 20-in. grillage beams. Each column is supported on five piles except at one corner of the building, where a column with a load of 350 tons is carried by three extra heavy piles having their tops capped by a single steel casting on which are seated grillage beams extending across the adjacent pier. In this way the five wall columns have been kept entirely within the thickness of the basement concrete walls. The remaining three columns in the Wall St. wall are located in the cellar, which extends beyond them under the sidewalk. Their footings are ordinary square piers reinforced with steel bars and supported by five piles each. They were built in open pits.

The general excavation was carried down to a depth of about 17 ft. below the curb, over the entire area of the building and the sidewalk vaults without necessity for pumping. At the street corner a 15-in. steam main runs diagonally from Broadway to Wall St., descending from the roof of the Subway to a lower grade. It is provided with two telescopic expansion joints. The necessary anchorages are in the form of concrete piers which occupy considerable space. The diagonal wall indicated in the plan had been constructed by the city at the time the Subway was built under Broadway. The steam main and wall were left undisturbed.

After the basement excavation was completed, 2-in. tongue-and-groove yellow pine sheeting about 6 ft. long was driven with a pneumatic hammer close to the faces of the walls of the adjoining building. A second row of sheeting gave a trench 3 ft. wide in which were driven the piles for the wall column foundations. A continuous reinforced concrete footing joining the heads of the piles was built along both sides of the lot to receive the column grillages and to serve as a footing for the concrete basement walls. Tongue-and-groove sheet piles 3 in. thick were driven around three sides of the cellar and thoroughly braced by 12x12-in. waling pieces and cross struts, before the cellar excavation was commenced. The piles on the Wall St. side were about 30 ft. long and were driven by a pneumatic hammer intended for driving bearing piles and equipped for this purpose with a special piece engaging the heads of the sheet piles. The remainder of the piles were about 16 ft. long and were driven by a lighter pneumatic hammer designed especially for sheet-pile work.

At the Broadway end of the building the Sub-

way of the Interborough Rapid Transit Co. extends inside the curb line and its east wall forms part of the basement wall. It was supported on the sand at a level just below that of the basement floor and, in making the cellar excavation under it, care was taken to support it at all times and to prevent the Subway from being undermined. As fast as the excavation was carried below the Subway, short vertical shores were wedged up under the wall of the latter and bulk-head boards were set up to retain the soil between them. The shores were replaced by longer ones as the excavation was deepened; when it was completed a wall of permanent horizontal sheeting boards was built from the bottom up behind them and the earth back-filled under the Subway and packed close against the boards to prevent any cavities there. An outside form was then constructed and the space under the Subway wall between the wooden shores was filled with reinforced concrete; after which the shores were removed and the cavities they had occupied were filled with concrete, thus completing a permanent retaining wall.

As soon as the cellar excavation was completed the lower ends of the sheet piles were braced with 12x12-in. struts extending across the full width of the excavation. Shallow trenches were dug around the four sides and in them the concrete footings of the retaining walls were built, with their upper surfaces beveled down toward the outer edge to provide bearing against horizontal thrust on the retaining walls. After the footing course was completed around the four sides of the cellar, two strips of the cellar floor 12 in. thick were laid across the cellar from wall to wall, between the foundation piers. These floor strips were reinforced by 1-in. horizontal steel rods 10 in. apart bedded in the upper part of the concrete. These served as struts to resist the horizontal thrust against the lower ends of the sheet piles and, later, of the retaining walls. The foundation pits for the three wall columns were sheeted far below the cellar floor and were kept dry by pumping until the piles were cut off at the required height; these were capped, the concrete filled in around them and the grillage beams set. Afterwards the remainder of the cellar floor was built and the retaining walls carried from the footings up to the basement floor level and braced with temporary wooden struts which replaced those originally provided for the sheet piling. The new struts resisted the exterior thrust until the steel floorbeams in the basement floor were connected. The retaining wall along Wall St. was then carried up to the height of the sidewalk beams.

The pile tubes are all open hearth steel $\frac{3}{8}$ in. thick and 12 in. in interior diameter. They are received in random lengths with both ends faced true and are driven by a pneumatic hammer of special construction, which is seated on the top of the tube and is provided with a vertical hole on the center line through which a jet pipe is inserted and can move freely. The nozzle at the lower end of this pipe is maintained at some point above the lower end of the pile so as to retain several feet of earth inside the pile while the latter is sinking. As the pile is driven down successive sections are coupled to the upper end with closely fitting inside sleeves of annealed steel. Each sleeve has two triangular lugs $\frac{3}{4}$ in. thick projecting from opposite sides at the center. The lower side of the lug is horizontal and is seated on the top of the lower section of the pipe, while the inclined sides fit a triangular notch in the lower end of the upper section of pipe; thus the lug prevents the sleeve from becoming displaced. The pipes are driven through hardpan to rock and the interior core is removed by jetting. The jet pipe, operated through the central opening in the hammer, is so designed as to cut up such hard material as is encountered. The jet is sup-

plied by a direct-acting steam pump having a 5-in. discharge. The stream coming away from the pile is led, by means of large canvas hose, to a sluice box which collects the solid material. The sluice discharges into a sump, over which is placed the force pump.

From four to eight vertical steel bars 2 to $2\frac{1}{4}$ in. in diameter and about 20 ft. long are lowered into the pipe and their upper ends held by clamps engaging them and seated on the end of the pipe. The upper end of each bar is then spliced to a second length and is lowered, clamped, an additional length spliced to it, and so on, until the lower ends of the bars are seated firmly on the rock. Two or three iron separators are then lowered to different heights in the pipe so as to space the bars symmetrically and the pipe is filled with grout or concrete to within an inch or two of the top. Splices in the bars are so distributed as not to come opposite splices in the pile tube. The bars are cut to such length as to leave their tops an inch or so below the top of the tube. Steel shims are fitted to the tops of bars to give them an equal bearing, with the tube, in a cast-iron cap, which encloses the top of the pile; this cap is grouted in position and receives the grillage beams of the pier.

An ingenious joint in the vertical bars enables them to be connected quickly and insures accurate bearing in the butt joints when in service. A short vertical hole is bored in the end of the bar with a special bit which has a shoulder limiting the depth of the hole. A cylindrical tenon with conical ends fits loosely in the holes and is secured by a transverse pin through each end of it and through the connected bars. These pins have clearance in their holes and are a little shorter than the diameter of the reinforcement bars so that they provide a loose joint. When, however, the bars are placed in final position, the tenons have end bearings, since the half-tenon length equals the depth of the hole in each of the abutting bars; thus provision is made for uniform bearing over the whole of the cross-section.

On this work piles having capacities of 75, 81, 87 and 117 tons were used. The 12-in. pipe before described was used in all of them, but the amount of reinforcement was varied to secure the desired capacity. The assigned load was less than one-sixth of the ultimate resistance, as determined by tests of full-size sections, of column length, containing one or more tube splices.

Excavation was commenced July 5; pile driving was commenced Aug. 4. The piers were completed Aug. 29. The balance of the work, including the erection of the steel work up to street level was finished Oct. 24, with a force of about 50 men working in each of two shifts. The size of the site and the governing conditions precluded the employment of a large force. Barnett, Haynes & Barnett, St. Louis, are the architects and the Westlake Construction Co., St. Louis, is the builder. Clark & Co., New York, were the contractors for the work here described, which was executed under the personal supervision of Mr. John S. Hyers, superintendent.

THE GEORGIAN BAY CANAL SURVEY has been completed after two years of work and a heavy expenditure of money. It is an undertaking comparable with the Panama canal, for the rough estimates of its cost already reach a total of \$125,000,000, and the revised estimates, based on the survey just finished, may be materially higher. The project calls for a channel with a minimum depth of 22 ft. from the Great Lakes to Montreal by way of French River, Lake Nipissing and the Ottawa River. Its completion would mean the shipping of cargoes from Great Lake ports to any part of the world without breaking bulk. How such a plan will appeal to the powerful trans-continental Canadian railways will not be seen until the report on the canal is made public.

The Bush Terminal Co. Factory No. 2.

The Bush Terminal Co. has extensive piers, docks, railroads and warehouses in Brooklyn, N. Y., and owns adjacent land on which it is planned to erect a group of large fireproof factories that will have important advantages from the service of the terminal. One of these factories has already been built and was fully illustrated in The Engineering Record of January 13 and March 3, 1906. Since then a second building of the same dimensions as the first one and adjacent to it has been constructed in which, although the general features of the first building were repeated, some interesting modifications were made in the arrangement, design and construction, and remarkable results have been attained in the increased rapidity and economy of construction.

The new six-story and basement building which is designated as factory No. 2, is 600 ft. long, 75 ft. wide and 110 ft. high above the cellar floor. It is built entirely of reinforced concrete and corresponds to factory No. 1, previously referred to, except in the arrangement of elevator and stairway shafts and columns, the length and capacity of floorbeams, the type of columns and the construction of the outer walls, all of which have been modified in the interests of economy and superiority as developed by the experience gained in the first building.

It is intended to rent each floor of the building to one or more manufacturing firms who will be provided with transportation, storage and elevator service, light and power, by the terminal plant. In factory No. 1 one pair of elevators are arranged in shafts at the extremities of the building and two pairs in a double shaft at the center. These serve all floors, with the maximum distance from any point to the elevator equal to one-quarter the length of the building, and correspond to a convenient division of the floors into halves and quarters symmetrical with the center transverse line. In the new building a more convenient arrangement has been secured by locating the eight elevators in two equal groups, each midway between the center transverse line and the end of the building, thus providing division lines for separating each floor into quarter portions at the ends and a half portion in the center if desired.

In factory No. 1, the floor was designed for a dead load of 95 lb. and a live load of 250 lb. per square foot. After completion several panels of the floor were subjected to a test load of 1,040 lb. per square foot, which produced a deflection of only $\frac{3}{8}$ in. In this building the floor was supported by three longitudinal rows of columns connected by longitudinal girders carrying transverse floor slabs 17 ft. 8 in. and 19 ft. 10 in. in length. Their deflection was so small under the heavy loading that, calculating deflections proportionate to the squares of the spans, it was considered justifiable to increase the length of the spans. Therefore in factory No. 2, the center row of columns is omitted and the side rows were placed at equal distances apart, dividing the width of the building into three 25-ft. spans.

The floor in No. 1 factory consists of a monolithic slab with deep ribs transverse to the axis of the building and supported on the $10\frac{1}{2} \times 31\frac{1}{2}$ in. longitudinal girders. The floor slabs have a minimum thickness of $3\frac{1}{2}$ in. and the ribs are 9 in. deep and 22 in. apart on centers. The ribs and longitudinal girders are reinforced with steel bars and their strength was considered so ample that their dimensions and reinforcement were retained without change in the longer spans of factory No. 2, the columns only being proportioned for heavier loads. The efficiency of the construction was verified by a test recently made by loading one 18×25 ft. panel with bags of cement aggregating 500 lb. per square foot over the total

surface. This produced a deflection which in three days gradually increased to $\frac{5}{8}$ in. After the load was removed, the deflection disappeared and no cracks or other evidences of injury were perceptible.

In factory No. 1, the columns are circular in cross section and are made with thin exterior shells of cinder concrete reinforced with expanded metal and a helix of steel wire and filled with stone concrete. In construction the shells were made to serve as moulds for the column and it was believed that considerable advantage was derived from their superior fire-resisting qualities and from the elimination of temporary column moulds. A careful analysis of the conditions convinced the contractors that equally satisfactory results could be obtained more quickly and cheaply by the use of temporary wooden moulds for the columns. The design was therefore modified in factory No. 2, where the columns have an octagonal cross-section and are built entirely of stone concrete reinforced by a continuous concentric helix of 5-16 in. wire with a minimum pitch of $2\frac{1}{2}$ in.

In factory No. 1, the wall spaces between the floors and the windows were filled with brick spandrel walls supported by the reinforced concrete wall girders and carried across the faces of the wall columns which were thus concealed, leaving the entire exposed surface of brick.

ing pieces built into the four corners. They were reduced in size to correspond with the reduction in the columns through the successive stories by reducing the size of the squares and by removing one of the pieces of which the corner filling pieces were constructed, these pieces having been so built at the commencement of the work that a piece could be taken out to correspond with the reduction of columns in each story. The columns were assembled on the floor and then stood up in position. A small section of each column form was left out near the bottom in order that any shavings or debris which might accumulate in the mould could be removed prior to concreting. The columns were cast before concreting the girders and floor. The concrete for the floors was cast monolithic from face of building to face of building, taking in sections of such lengths as could be handled in one day. The exterior wall columns were constructed in a similar manner to the interior columns excepting that their cross sections were rectangular.

The curtain wall forms were constructed of $1\frac{1}{8}$ -in. tongue and groove spruce lumber made up into panels by nailing to 4×4 in. standards. These forms were bolted together near the bottom and at top immediately above the sill. After concreting the bolt holes were carefully pointed up with Portland cement mortar.

The construction of the forms for the girders



Test Load of 500 lb per Square Foot Sustained without Injury on third Floor.

In factory No. 2 all brick work has been eliminated. The concrete wall columns were moved outward 4 in. to come to the building line. Bevel strips were nailed to the exterior column forms to divide up the large wall columns into blocks and in order to break up the plain surface and add to the appearance of the exterior. The wall girders are framed into the columns and carry the concrete curtain walls; these walls are built subsequent to floors and columns, and are keyed to the columns, filling into recesses left in the sides of the columns. The exterior surface is paneled by nailing bevel strips on the inside of the exterior forms. Window sills are cast monolithic with the walls and the surface is troweled hard and smooth.

The 152 interior and exterior columns have pile foundations with concrete footings reinforced according to the "Bertine" system, which was also adopted for the main girders. The interior columns are octagonal, splayed out at the top to a square in order to simplify the framing of the beams and girders into them. The forms for the columns were constructed of $1\frac{3}{4}$ -in. tongue and groove spruce lumber nailed to 4×6 in. cleats, which in turn were bolted to take up the bursting pressure during the process of the concreting. In order to form the octagonal face the column moulds were constructed first as squares and fill-

and floors was identical with the construction in factory No. 1. The trough shaped forms for the floor slabs which were used in factory No. 1 were lengthened out for the longer spans, thereby utilizing considerable lumber which has been used in the first factory. The forms were constructed for one complete story and were sufficient to permit of continuous work on the part of the concrete laborers. All forms were thoroughly coated with petrolatum prior to concreting. Sand and gravel were delivered on a railroad track alongside of the building and shoveled by hand into the storage piles in the basement.

The plant included two Ransome $\frac{1}{2}$ -yd. mixers, one located in each elevator shaft, so that the maximum wheel of concrete was 150 ft. The mixers were driven by 10-h.p. motors and discharged directly into $\frac{1}{2}$ -yd. Ransome automatic hoist buckets elevated by means of independent electric hoists and dumped into inclined concrete boxes on the working floors. Cement, sand and gravel were delivered to the mixers by wheelbarrows and the concrete was conveyed from the chutes on the floor to the work in Ransome two-wheel dumping carts. All concrete was mixed in the proportion of 1 part Atlas or Alpha Portland cement; 2 parts Cowboy sand and 4 parts $\frac{3}{4}$ -in. washed gravel.

The contract called for the roof to be finished:

by Dec. 1st; concreting of the basement columns was commenced July 23d and the roof was completed Oct. 27th, more than one month earlier than the contract date. In this period of 74 working days, over 13,200 yds. of concrete was mixed and placed and over 775 tons of steel was fabricated and erected in the work. Each floor had an area of 45,000 sq. ft. and the six floors and roof were, therefore, constructed at an average of $10\frac{1}{2}$ days to each story.

The constructions of the curtain walls, interior-partitions and stairs were kept closely behind the other work, and the speed attained on this building establishes a new record for rapid construction in reinforced concrete. The working force consisted of about 80 carpenters and 180 laborers. The general structural design was prepared by Mr. E. P. Goodrich, formerly chief engineer for the Bush Terminal Company. The change from brick walls to concrete exterior was suggested by the architect, Mr. William Higginson, and this

The Removal of Iron from the Water Supply of Reading, Mass.

The water supply of Reading, Mass., has long been considered a particularly interesting one on account of the iron it contains. It is drawn from a filter gallery and the water-bearing stratum in which it is placed is overlaid by soil containing much vegetable matter. When the ground is not frozen, a considerable amount of surface water enters the gallery, while it is probable that ground-water from the neighboring river furnishes a large part of the supply in the gallery when the top soil is frozen and the river is high. The iron in the ground water, in the absence of large amounts of organic matter, can be readily removed by aeration, subsidence and filtration, but the organic matter, if present in a large amount, may prevent the precipitation of iron even after thorough aeration and subsidence. As

Lewis M. Bancroft, decided to conduct experiments for a sufficient period and in enough detail to determine what could be done with the water in any condition likely to occur. From Aug. 24, 1904, to April 27, 1905, experiments were accordingly made where iron was added to the water by direct contact, and from Feb. 27, 1905, the iron was added electrolytically when needed, this process being still followed when Mr. Robert Spurr Weston made the report on the work from which the following notes are taken.

The State Board of Health recommended that the water be treated by contact with iron in a reservoir. It recommended that the iron be in the form of strips, so that they could be removed from the water and scoured whenever they should become corroded. The experiments with the revolving drum were a modification of this device, with a view to decreasing the expense of treatment. During the experiments the water was passed through a revolving barrel containing par-



General View of Erection of Bush Terminal Co.'s Building Showing Floor and Column Moulds and Centering.

portion of the work was re-designed by the contractor, the elevations being, however, prepared by Messrs. Kirby, Pettit & Greene, consulting architects. The Bush Terminal Company provided all materials and the Turner Construction Company was general contractor for all labor, plant and superintendence.

THE BELEN CUT-OFF of the Atchison, Topeka & Santa Fe Ry. between Mexico and Rio Puerco, New Mexico, has been completed and is being placed in operation. The cut-off is 269 miles in length, connecting two points on the Texas and New Mexico divisions, and while but 12 miles shorter in mileage between Kansas City and the West, it cuts off two mountain ranges with 228 miles of $3\frac{1}{2}$ per cent. grades and substitutes one mountain range with only 25 miles of $1\frac{1}{4}$ per cent. grades. It will shorten the time of through passenger trains several hours and save about a day's time for freight trains.

the two classes of water are mingled in the gallery in proportions which fluctuate greatly and rapidly, the problem of purification is a complicated and difficult one.

In 1892 Mr. Desmond Fitzgerald advised the water commissioners to purify the supply by aeration, protracted subsidence and filtration. Three years later the State Board of Health advised abandoning the supply and purchasing water from the Metropolitan Water Board, but suggested as a temporary relief some system of mechanical filtration. Accordingly Warren filters were introduced and have since been used. While they remove the iron to a satisfactory degree, they increase the hardness three-fold. After extensive experiments in 1903, the State Board of Health advised the commissioners to treat the aerated water with metallic iron and to follow the treatment with filtration at a moderate rate through sand. Before planning works for this purpose, the commissioners and their superintendent, Mr.

ticles of iron. The barrel was connected with an aerator, subsiding basins and sand filter, in such a way that the following combinations could be experimented with: (a) Iron treatment and filtration; (b) iron treatment, aeration and filtration; (c) iron treatment, subsidence and filtration; (d) iron treatment, aeration, subsidence and filtration.

During these experiments the iron gradually penetrated the sand layer and finally appeared in the effluent. The increase in the period of subsidence did not overcome this trouble, neither did resting and aerating the sand layer. The deep scraping of the filter and replacing of fresh sand therein bettered the results for a time only. In view of the expense of operating this process on a large scale, owing to the expensive construction involved and the power required to revolve large drums containing scrap iron, and also in view of the possibility of failure of the plant in practice, because no guaranty could be made that

the water by direct contact with the iron would always take to just the suitable and proper amount of iron at all times of the day and year for the proper treatment of the water, it was decided to abandon the experiments with this process and to substitute the barrel containing pieces of iron, iron plates through which electric current could be passed.

When these plates, arranged in pairs, are immersed in water to be treated and one of each pair of plates is connected with the positive and one with the negative pole of some machine for producing electric current, the water is decomposed and iron is added to the water in the presence of oxygen, in the form of ferric hydrate—a reddish brown precipitate. The electric current possibly effects a decomposition of combinations of iron and organic matter which are exceedingly difficult to remove from the water by aeration and subsidence. The excess of iron added has the effect of neutralizing the organic matter and by its absorptive power it carries down with it the iron originally present in the water, which, being precipitated with the iron added electrolytically, is either retained in the subsiding tanks or is removed by the filter when the treatment is carried to the proper degree. The effect is similar to that produced by the contact of the water and iron. The advantage of the electrolytic device lies in the fact that the iron surface exposed may be very much reduced and that the amount of iron added to the water is always under the direct control of the attendant, because, other things being equal, definite amounts of electric current discharge definite amounts of iron into the water as it comes in contact with the plates. This advantage is further increased because of the greater convenience and by the reduced cost of operation.

The results of these experiments are given in an accompanying table.

EXPERIMENTS WITH ELECTROLYTIC IRON DEVICE, 1905.

From	To	sub-sidence	Iron, parts per 100,000	Treated Wells	Filtered Aerator
Feb. 27..	Apr. 1..	30	0.118	1.025	0.009 Used
Apr. 2..	Apr. 26..	24	0.109	(a) 0.844	0.020 Used
Apr. 27..	May 12..	48	0.100	(b) 1.067	0.017 Used
June 1..	June 7..	48	0.099	1.212	0.016 Used
June 8..	June 21..	48	0.106	(c) 1.392	0.052 Used
June 22..	Aug. 5..	60	0.114	(d) 1.910	0.112 Used
Sept. 15..	Oct. 14..	30	0.141	(e) 1.270	0.006 Unused
Oct. 14..	Oct. 26..	39	0.168	1.500	0.000 Unused
Oct. 26..	Nov. 11..	24	0.207	1.200	0.002 Unused
Nov. 11..	Nov. 17..	48	0.200	1.100	0.000 Unused
Nov. 17..	Dec. 13..	48	0.190	(f) 1.089	0.002 Used
Dec. 13..	Dec. 31..	48	0.174	(g) 0.241	0.000 Unused

(a) Idle, April 9 to 14. (b) Stopped by failure of dynamo. (c) Filter idle one day. (d) Filter went out of service. (e) Ten inches of new sand added. (f) Eleven days idle. (g) No electric current.

It will be seen from the table that with the exception of the period during June and July, the filters gave excellent results, and for the last five months almost entirely removed the iron from the water without increasing its hardness. When the inferior results were obtained, the filter was being operated at a rate of 5,000,000 gal. per acre per day, and the water was subjected to about 48 hours subsidence, preceded by aeration. The unfiltered water contained about two parts of dissolved oxygen per million. Strange to say, when aeration was omitted the efficiency of the filter was soon restored, and since that time no difficulty has been experienced in treating the water when the theory learned from this experience has been applied.

When ground waters like the Reading water are pumped to the surface, they are clear and when the amount of iron is high, they possess an inky or styptic taste. After standing for some time, however, the water first becomes opalescent, then turbid, and finally the particles producing the turbidity darken in color (or rust), gather in "flocks" and precipitate, leaving the water above the sediment clear, tasteless and almost free from iron. The above clouding and clearing of the water is caused by the changing of the iron from the unoxidized or soluble into the oxidized or insoluble form. The speed of this reac-

tion depends upon the composition of the water, as will be shown beyond. The Reading water very often requires a long time for the complete precipitation of the iron, while the iron-bearing artesian waters of the Jersey coast precipitate within a few hours. Chemically considered, the process may be divided into four parts:

1. The absorption of oxygen from the air by the water.

2. The breaking down of the iron compound originally contained in the water into a compound that may be oxidized. This process is called hydrolysis.

3. The oxidation of the iron into the colloidal or gelatinous form of iron hydrate which though oxidized is, like starch, so peculiar in structure that it remains in a state bordering upon solution (in this state it would not be retained by a filter) until

4. The iron hydrate gathers together into "flocks" or aggregates, and precipitates as the hydrated iron oxide or, as it is generally called, iron-rust.

The chemistry of this process is rather complicated and the action is retarded by the presence of many interfering substances, particularly carbonic acid and the organic acids which form a part of vegetable matters. Aeration serves to remove carbonic acid, and at Reading the experience shows that the organic acids may be removed either as at present, by neutralizing with lime, or as tried during these experiments, by adding metallic iron to the water either by contact or with the aid of an electric current. The compound resulting from the action of these organic acids and metallic iron seems to be oxidizable, and furthermore, this added iron combines with and removes the organic matter which interferes with the oxidation and precipitation of the iron originally contained in the water.

It has been the opinion in Europe and in this country that aeration could never be overdone, but the experiments at Reading show that when the water is of a certain character, the small amount of oxygen dissolved in the gallery waters effects a better removal of the iron than a large amount of oxygen added by artificial aeration, as was shown when the inferior results of last July were obtained. It is believed at the present time that when the water is aerated in an excessive degree it causes the rapid precipitation of the iron added electrolytically before it has time to combine and absorb the iron originally present in the water.

This phenomenon was demonstrated by experiments conducted in gallon bottles, which were filled with water and were allowed to stand 24 and 48 hours, after which the iron remaining in the water above the sediment was determined. Experiments were made with the water before and after treatment with iron, which was added electrolytically. These experiments proved conclusively that for days at a time the iron in the aerated water, after treatment with iron (electrolytically) subsides much more rapidly than the unaerated water, while on the other hand, the unaerated gallery water precipitates its iron much more rapidly than after it is aerated. This goes to prove that the added iron and the original iron precipitate at different speeds, and it is the object of any plant designed to treat the Reading water to cause these precipitations to take place at about the same rate and time, in order that the larger amount of added iron when precipitating may induce the removal of the iron originally present in the gallery water.

During December, 1905, it was necessary to add very little iron to the water to affect its satisfactory purification. In fact, during part of the month no electric current was used, yet the iron removal was complete. On the other hand, the water may at times require as much as 0.8 parts per 100,000, although recent experience indicates

that much smaller amounts of iron will be necessary in the future on an average than were thought necessary at the beginning of the tests. The greater the amount of iron added, the shorter the period which the filter can be operated without scraping its surface. Therefore it is an advantage to add as little iron to the water as will effect purification.

The length of periods between scrapings has varied greatly. During some of the experiments it has been of only about ten hours duration; again the period has been over 160 hours. It should be borne in mind in this connection that the experimental filter has only 1 ft. depth of water above the surface of the sand, and that in practice filters are built with a water depth of 4 ft.

During the first part of the year considerable trouble was experienced with the clogging of the filters with air. This difficulty was overcome by suitable devices for filling the filter from below, and when the report was written the filters were running for about 5 hours a day for about three weeks at a time.

The addition of iron at certain times of the year, especially at the time when the amount of organic matter is high, is absolutely necessary for the satisfactory purification of the water by this method, but for the greater part of the year it is probable that little or no electricity would have to be used with the iron plates. This method of adding iron to the water, applied for the first time in this connection, has worked with entire satisfaction, the amount of iron used being at all times under the direct control of the attendant.

When the water is properly treated it seems to make no difference whether the filters are operated at a rate of 3,000,000, 6,000,000, or 10,000,000 gal. per acre per 24 hours. In other words, the treatment of the water is all important; the rate of filtration relatively unimportant. It is not believed, however, on account of the comparatively short periods between scrapings, that rates much higher than 10,000,000 gal. per acre per 24 hours could be used to an advantage.

THE GROUTING OF MASONRY PIERS has been done successfully on the Drammen & Randsfjord Ry. in Norway. The piers were built of massive gneiss blocks, bonded and partly held together by iron clamps. The interior was made up of smaller stones, and all cavities were filled with hydraulic mortar. In the course of years, with varying height and strength of current, the water penetrated inside the piers and began to form internal cavities. Attempts were made to remedy this by filling with cement mortar all holes that could be got at and repointing the joints, but the result was not satisfactory. A number of holes were then made with the object of opening out all the internal cavities, which were then scoured by a jet of water from a force-pump. One hole, made a little below the top of the ice-breaker at the upper end of the pier was found to communicate with a joint near the bottom of the lower end; the intervening distance was about 43 ft. with a fall of 10 ft. In each of three boxes equal parts of cement and sand were mixed dry, water was added, and the whole was worked into a uniform paste. Each batch when ready was emptied into a tank large enough to hold a charge of 3.18 cu. yd. It was kept continually stirred until drawn off by a force pump and injected through flexible hose into one after another of the holes. Great care had to be taken to empty the tank, pump, and hose after each time of using; otherwise the cement mortar would harden quickly in them. The pump packings wore rapidly and required renewal. According to the quantity of cement used, the cavities filled must altogether have amounted to as much as 26.9 cu. yd. The pier has thus been rendered water-tight. It took only 32 minutes to inject the charge of 3.18 cu. yd.

The Steelwork of the City Investing Company's Building, New York.

A general description of the building in course of construction for the City Investing Co., New York, was printed in The Engineering Record of Nov. 24, and it is proposed in this article to give some notes concerning its steel superstructure. The columns are seated on cast steel pedestals designed to extend their narrow bases and distribute the loads uniformly over the top flanges of the triple foundation girders described in the previous article, or across the upper tier of I-beams when the columns are seated directly on the grillages. An exception is found in the five-story columns 56, 57, 63 and 64, which terminate at the roof in the bottom of the light court. The loads they carry are comparatively small and their special pedestals are seated directly on the granite caps of the piers. The maximum load is 269 tons, and the 22x22-in. base plate of the column is bolted to the top of the pedestal 16 in. high, with its square base extended to a width of 3½ ft. and stiffened by an outside flange 3 in. high and by twelve radial ribs 1¾ in. thick, which diverge from a vertical cylindrical center diaphragm 15 in. in diameter and ½ in. thick, which unites the top and bottom plates of the pedestal.

The four twin columns, 1, 2 and 3, 4 in the face wall of the Broadway wing have loads of 535 and 605 tons each and are seated in pairs on spe-

cial pedestals 7 ft. long, which act virtually as distributing girders to give uniform loading to the ten grillage beams under each pair of columns. The pedestals are of the simplest possible construction with a 1 ft. 10 in. x 6 ft. 7 in. top plate and a 7x3-ft. baseplate connected by two longitudinal webs 2 in. thick and 7 in. apart in the clear, and by eight transverse webs 1½ in. thick and from 7½ to 10 in. apart in the clear. The pedestal is 30 in. high; its cap plate is drilled with eight anchor bolt holes for each column and the base plate is drilled for four anchor bolts to the grillage and is planed on the lower side. All of the columns which are seated on the triple-web distributing and cantilever girders described in the previous article have pedestals with 2½x5-ft. bases, four longitudinal and four transverse vertical webs, as indicated in the drawing for pedestal 9. Nineteen pedestals are made like this and the remaining sixteen differ from it only in the width of the cap plate, which is reduced to 2 ft. 2 in. or 2 ft. 8 in.

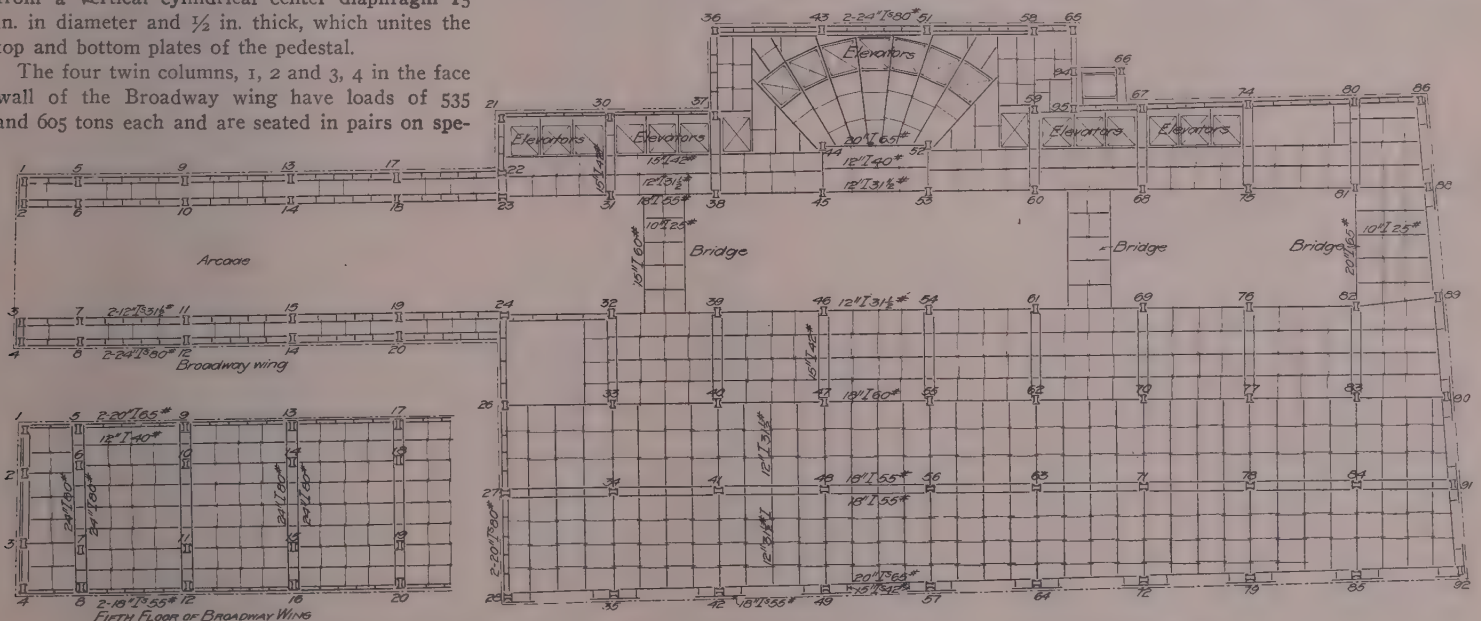
Five columns with loads of 865, 857, 740, 666, and 857 tons transmit their loads directly to the grillage beams through pedestals similar to those for column 56, but having larger dimensions, the bases being 5 ft. and 5½ ft. square. The remaining thirty columns have heavier loads, and in order to provide for considerable extension of the pedestal base beyond the column base, the pedestal is made with upper and lower pieces bolted together through their horizontal flanges as indicated in the pedestal for column 47. These pedestals are made in three sizes, varying both in height and in lateral dimensions. In one set, the upper castings are made as shown, with longitudinal and transverse webs, and in the other sets they are made with a center cylinder and radial webs similar to the pedestal for column 56. The lower castings are all similar to that shown. The pedestals for all columns have their corners filleted and are made of medium steel of an ultimate strength of 60,000 to 70,000 lb. and annealed.

All columns are made of medium open hearth steel and have rectangular closed cross sections made with two rolled or built channels and flange cover plates. The loads of the full length columns vary from 525 tons to 1,719 tons, with corresponding sectional areas of 101 and 263.6 square inches. The upper stories of the latticed columns have a sectional area of 22.2 square inches made up with two 25-lb. channels and two 12x5/16-in. cover plates. The maximum section is made with four 6x6x¾-in. angles, six 20x13/16-in. web plates, six 22x13/16-in. cover plates and two 10x¾-in.

These plates are parallel with the column webs extending horizontally beyond their flanges and engaging special connection angles riveted to the outsides of the cover plates as shown in the diagram. This arrangement provides connections about 4 ft. deep for the 24-in. I-beams and 28 in. deep for 18-in. I-beams, and makes all field rivets accessible for advantageous driving.

Interior columns have transverse floorbeams directly connected to their webs which interfere with the continuity of the girders across the sides of the columns. These are made with pairs of vertical connection angles riveted to the edges of the cover plates to receive the ends of the girders which are cut to clear the columns. The floorbeams butt against the column webs and are seated on reinforced shelf angles. This arrangement provides for symmetrical balanced loads on all columns and secures deep connections and easily driven field rivets.

The Broadway wing is about 37½ ft. wide, 104 ft. long and 355 ft. in height above the curb. The protection now afforded to it by adjacent buildings has been disregarded in calculating the wind stresses, and these are so large that special transverse bracing was required to provide sufficient



Column and Girder Plans of Ground Floor and of Fifth Floor of Broadway Wing.

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The Broadway wing is about 37½ ft. wide, 104 ft. long and 355 ft. in height above the curb. The protection now afforded to it by adjacent buildings has been disregarded in calculating the wind stresses, and these are so large that special transverse bracing was required to provide sufficient moment of resistance. This is secured in the upper stories by the deep connections already described, but below the third floor the full width of the wing is occupied by the arcade, 44 ft. in height, where the unsupported length of the column is too great for ordinary construction to resist the bending moments and where the architectural considerations precluded the use of transverse knee-braces or diagonals.

Above the third floor, there are two intermediate rows of columns 18 ft. apart on centers and 8 ft. from the wall columns. In the arcade, the interior columns are eliminated, therefore the twenty-three upper stories are carried on heavy box girders spanning the arcade and supported by the wall columns to which they are web-connected as indicated in the drawing. All of these girders are made with two double webs, the pair of plates for each web being riveted to opposite sides of the flange angles as indicated in the cross section. Fillers are placed between the web plates only at points where vertical web stiffener angles are riveted to the outsides, in the lines of the column centers and for the intermediate panels. The 1-in. girder rivets have holes punched 15/16 in. and reamed to 1 1/16 in.; the ¾-in. column connection rivets have 13/16-in. punched holes reamed to 15/16 in. The depths of the girders vary from 65 in. over all at columns 23, 24 to 92 in. at columns 9-12, 13-16 and 17-20. These gird-

ers are all riveted up complete at the shops and have a maximum shipping weight of about 60,000 lb.

Below these girders, the wall columns are reinforced by practically continuous web connections to duplicate columns 4 ft. 4 in. distance from them on centers in the same transverse planes, thus virtually transforming the two twin members of the lower parts of the wall columns into vertical plate girders with closed rectangular flanges like chords of bridge trusses. The upper ends of the

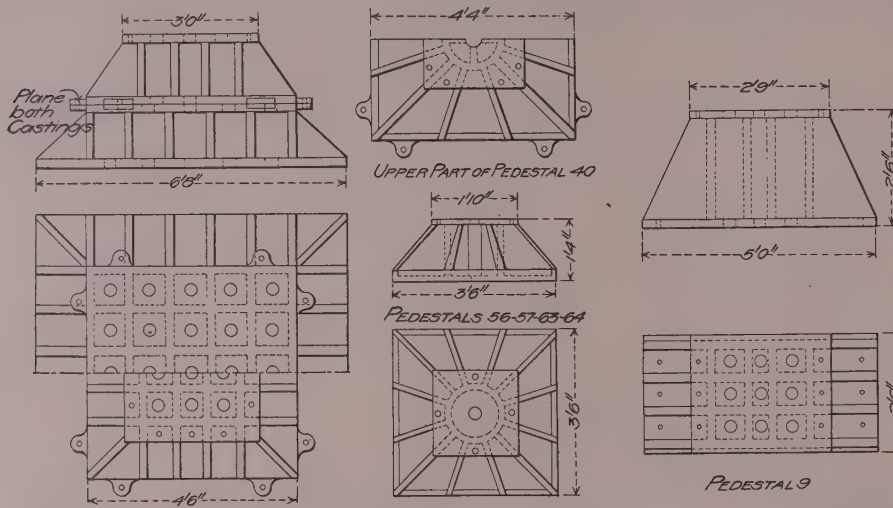
outside ones riveted over the outer faces of the webs. The framing in the corner panels of the Cortlandt Street wings is special as indicated in the diagram of the seventh floor, which corresponds essentially to the construction up to the twentieth floor. The corner columns are connected by a girder which serves as the fulcrum for the diagonal cantilever girder projecting toward the light court and connected at their extremities with the curved wall girders. The corner of the building at the south end of the Trin-

ity Place front is similar to the corner here shown.

At the eleventh floor, the framing is modified by the omission of the shafts for the center group of elevators which are here discontinued, and at the nineteenth floor it is again modified by the omission of the group of elevators at the Trinity Place end of the building, leaving only the group nearest the Broadway wing to serve the stories above; the space occupied by the discontinued shafts being of course utilized for office purposes and having floor panels corresponding to extension of the regular system.

At the twenty-third story, the framing in the corner of the light court and on Trinity Place is modified by the omission of the curved wall girders, the pairs of corner columns being united by diagonal beams similar to those which in the lower story served as chords for the curved girders. In the twenty-fourth story, these diagonal beams are moved inwards and smaller curved girders with re-entrant angles at the ends are substituted to conform with the architectural requirements, and construction is continued up to the cornice.

At the twenty-seventh floor, the Broadway wing terminates but the main part of the building continues with framing similar to that in the lower story, except that on the east and west side of the building the transverse girders are single instead of double lines of I-beams, the elevator shafts are discontinued and a new elevator is provided near the center of the south side of the building.



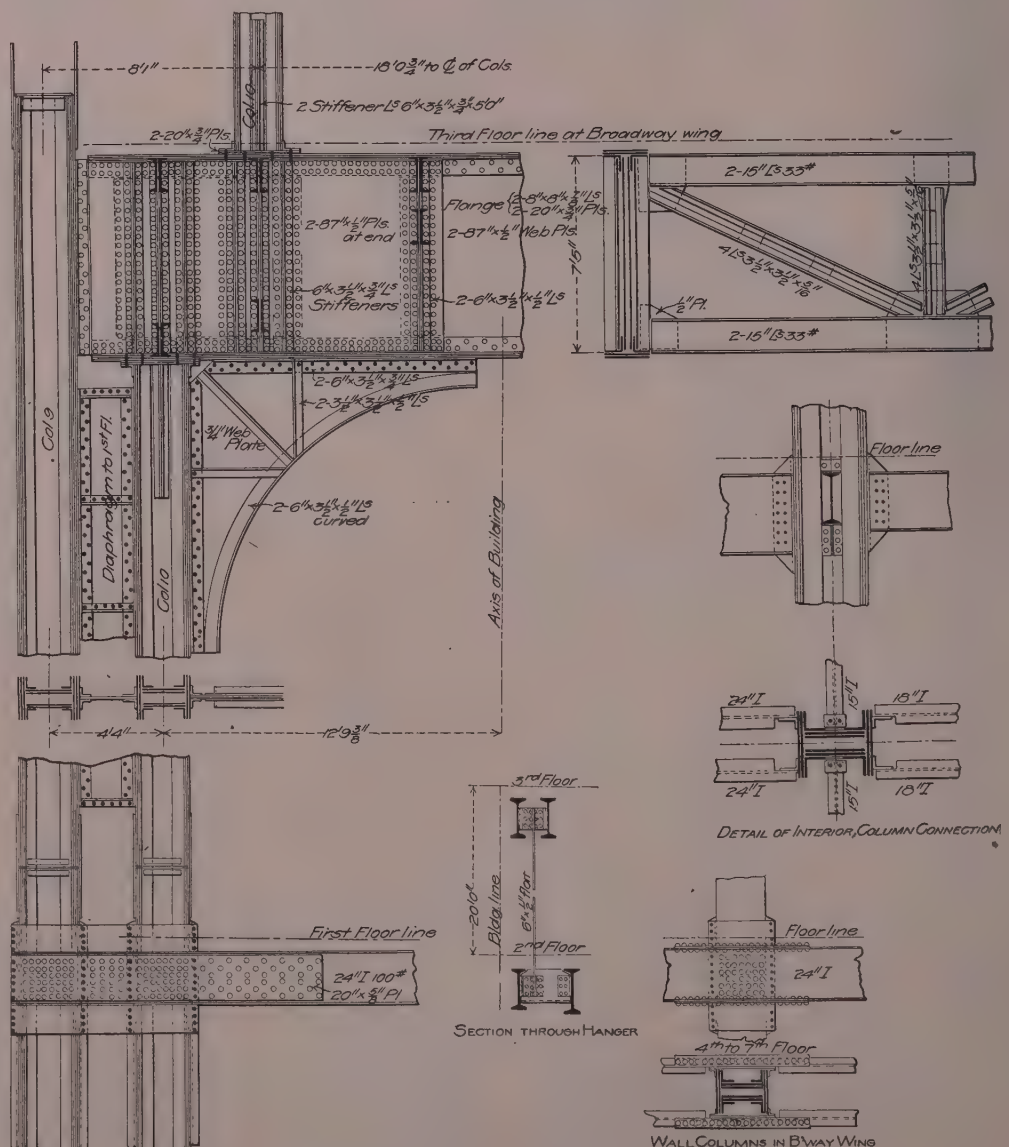
Details of Column Pedestals.

inner twin columns are braced by curved portal struts to the lower flanges of the box girders, thus adding to the lateral rigidity and securing enormous stiffness against wind pressure. The box girders at third floor level are braced together by sway frames parallel to the long walls of the wing and are concealed by the vaulted ceiling built on metallic lath suspended from them. The lower parts of the columns are braced by transverse girders in the first and basement floors.

The arrangement of beams and girders in the floors is very simple, all of them being located substantially at right angles to each other in regular panels. The second floor arrangement is special on account of the omission of most of the floorbeams in the line of the arcade from Broadway to Trinity Place and the special arrangement in the Broadway wing each side of the arcade. Bridges cross the arcade at this level over the Trinity Place entrance and at two intermediate points adjacent to the elevators. These are shown by the diagram and the remainder of the floor plan in the main part of the building is substantially typical of that in the other floors up to the 26th floor. In some cases the second floor wall girders are bracketed out so far from the column girders that they are additionally supported by hangers from the third floor wall girders as shown in the detail. In the fourth floor and all those above it the beam plan is modified by the omission of all beams and girders in the light court, which includes the area between columns 49, 47, 70 and 72, and the regular floor construction is extended over the arcade.

In all of the floors above the third, the transverse girders in the Broadway wing are made with pairs of full-length I-beams extending from wall column to wall column to give additional rigidity against wind pressure. The depths vary from 15 in. in the twenty-fifth floor to 24 in. in the fourth, fifth, sixth and seventh floors.

Above the skylight at the foot of the light court, the corners of the Cortlandt Street wing are rounded and the curved wall girders are supported on columns set back a few feet from the angle and supported on special plate girders in the sixth floor tier which carries the construction up to the roof line. These girders are 48 in. deep with three webs, the center one riveted between the vertical legs of the flange angles and the two



Details of Column and Girder Connection.

At the twenty-seventh floor, the roof construction commences and the dimensions of the successive stories diminish rapidly in accordance with the slope of the steeply pitched roof. The rafters are single channels extending continuously from the walls to the peak and supported at every story by horizontal beams and columns, the latter being seated on transverse girders in the floor below. The rafters carry 8-in. channel purlins covered with 3x2½-in. 5-lb. horizontal T-bars 25 in. apart on centers. The dormer windows are made with semi-circular head frames forming arch ribs of 17-ft. span trussed with diagonal braces and covered with T-bars to carry the sheathing.

Mr. Francis H. Kimball is the architect; Weiskopf & Stern are consulting engineers and designed the steel construction and foundations; the Hedden Construction Co. is the general contractor. The steel will be furnished and erected by Post & McCord.

Evaporation of Ground Water.

Experiments made by Prof. Charles S. Slichter in Western Kansas show that a considerable amount of stored ground water is lost in the

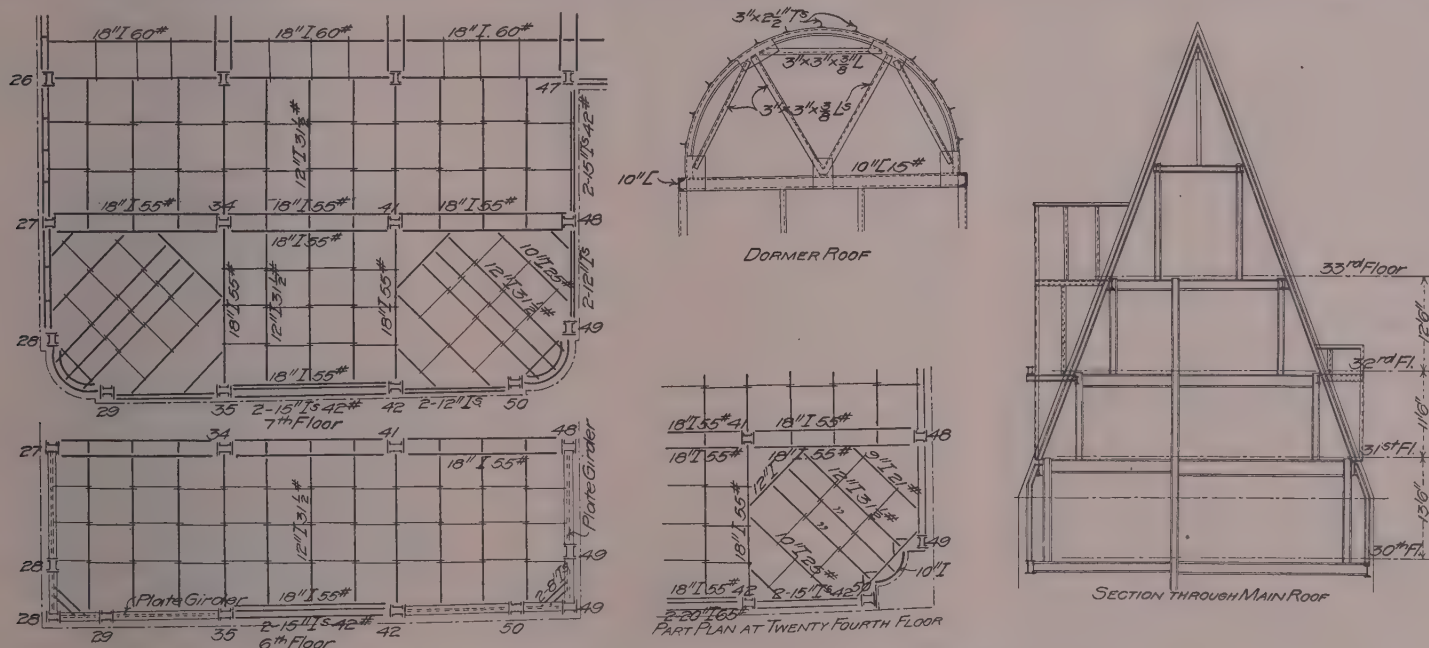
Flood Control and Conservation of Water Applied to Passaic River.

Paper read before the New Jersey Sanitary Association by Mr. Morris R. Sherrerd.

For many years the possibility of the conservation of the waters of the Passaic River, both for power and water supply purposes, has been discussed, and many reports have been made on the subject, particularly in connection with the Geological Survey of New Jersey, but it was not until the devastation which was occasioned by the recent disastrous floods on the Passaic River, namely, those of March, 1902, and October, 1903, made the question of flood control one of sufficient importance to warrant a thorough investigation of the possibility of such control, that the subject received as much attention as its importance deserved. The field work of the Passaic River Flood District Commission is completed, and careful surveys to determine the cost of the construction of a dam at Mountain View, N. J., both on the basis of flood control and conservation of water, have been finished. The compilation of these data in satisfactory shape for presentation to the public is still in progress and, therefore, it would be somewhat premature to do more than

problem by the two commissions referred to, the membership being the same in each, the unanimous judgment of the commissioners is that nothing has developed to change the previously expressed opinion on this subject. For purely flood control purposes, either proposition is so expensive as to require serious consideration as to whether the benefits to be derived are sufficient to justify the necessary expenditure. Any combination or further development which would result in producing revenue tending to make the scheme self-sustaining becomes essential in the study of the problem; also the wisdom of conserving the water supply of the State for the use of its inhabitants is becoming from year to year more apparent, and while perhaps the immediate needs of the metropolitan district of New Jersey, embracing Newark, Jersey City, Paterson, Hoboken, the Oranges, Montclair, Elizabeth and the smaller communities adjacent thereto, are not pressing, none of the territory is adequately provided for water supply for more than 20 years, and some are already seeking additional potable water.

On account of this situation, this district hardly feels justified in joining in present expenditures for conservation for which it has no present use, but the subject is one which should be consid-



Part Floor Plans and Roof Sections, City Investing Company's Building.

first bottoms of the Arkansas River by evaporation. Although the measurements extended over only a very brief period, he considers them sufficient to establish the fact that the loss of ground water by evaporation is about ten times as great where the water is within 1 ft. of the surface of the ground as it is where the water table lies at a depth of 3 ft. The pumping plants that materially lower the ground water in the bottom lands will thus save a considerable amount of water that now goes to waste in evaporation and in supplying the rank growth of wild grasses that flourish in the first bottom lands. Prof. Slichter estimates that this savable loss amounts on the average to a foot of water for each acre of first bottoms during the months of July and August alone. Observations of evaporation were made by means of three tanks filled with natural soil in which the water plane was kept at a constant elevation, and the evaporation from an open tank was also determined. The rainfall, vapor pressure, percentage of relative humidity and velocity of the wind were also observed, but do not affect the main purpose of the experiments. At a depth of 3 ft. below the surface, the ground water evaporation was from 0.4 to 0.17 in. and at a depth of 1 ft. it was 0.7 to 1.73.

give a general outline of what the possibilities are in connection with the subjects under investigation.

Any adequate plan for flood control on the Passaic River must of necessity provide sufficient storage to hold back and retard the flood discharge through the lower valley below Little Falls sufficiently that the amount of water, which is allowed to pass down the river, may safely be carried by a reasonable adjustment of the present restricted channel.

In the report of the Northern New Jersey Flood Commission submitted to the Legislature in March, 1904, this whole subject was thoroughly discussed and the conclusion of the Commission was that while the construction of a reservoir with a dam at Mountain View of sufficient height for flood control purposes was estimated to cost \$3,460,000, which would be about \$900,000 more than the cost of the construction of a retarding reservoir with a dam located at Little Falls, still the former location would lend itself so admirably to conservation purposes that it would be a much more satisfactory location and eventually work out much more economically than the Little Falls plant.

During the three years' study devoted to this

ered in its broad sense as affecting the prosperity of the State. Certainly an adequate conservation plan, which will be able to supply the needs of the several communities as they develop could be much more economically carried out on broad lines, even if done at the joint expense of the communities themselves, than if each one were to supply its own needs independently.

The conservation of water by the State, under the present Constitution, unless such conservation can be made at once self-sustaining, would seem to be limited to the expenditure allowed by the Constitution of \$100,000. There is, however, a provision in the Constitution which would allow the issuing of bonds for such work as the construction of a reservoir on the Passaic, provided the interest and sinking fund for such bonds are taken care of without pledging the State's revenues. Such a work, however, can only be constructed after a law for the same has been submitted and approved by a majority vote of the people of the entire State. This is shown by the following paragraph of the State Constitution:

Sect. VI, Clause 4.—The Legislature shall not in any manner create any debt or debts, liability or liabilities of the State, which shall singly or in the aggregate with any previous debts or liabili-

ties any time exceed one hundred thousand dollars, except for purposes of war, or to repel invasion or to suppress insurrection, unless the same shall be authorized by a law for some single object or work to be distinctly specified therein; which law shall provide the ways and means, exclusive of loans, to pay the interest of such debt or liability as it falls due, and also to pay and discharge the principal of such debt or liability within thirty-five years from the time of the contracting thereof, and shall be irrepealable until such debt or liability and the interest thereon, are fully paid and discharged, and no such law shall take effect until it shall at a general election have been submitted to the people, and have received the sanction of a majority of all the votes cast for and against it at such election; and all money to be raised by the authority of such law shall be applied only to the specific object stated therein, and to the payment of the debt thereby created. This section shall not be construed to refer to any money that has been, or may be, deposited with this State by the government of the United States.

Broadly stated, the development of a storage reservoir with a dam at Mountain View, which could be utilized by keeping the upper part of the reservoir for flood-control purposes, would cost in the neighborhood of \$6,000,000. This cost includes land for the reservoir, the construction of a dam, necessary changes of railroads and highways and the re-location of the Newark pipe line and the Morris Canal, all based on careful estimates made up from actual surveys. This would provide storage in addition to flood control, but does not include any estimate for diversion rights of the mill owners below, but would provide sufficient storage to allow a uniform discharge to the river below the dam, which would more than compensate the mill owners for any loss of power, so the damages in any event would be nominal. This would be on the adoption of the principle of substitution or compensation for diversion, and while such a principle has not been established in New Jersey, it would seem to come within the scope of the State's power of eminent domain. In other words, while it would not now apply to individual diversion, it might be applied by legislation to diversion made by the State itself. In fact, such a substitution of increased flow in the river would be a benefit to the water powers below, which they might reasonably be required to pay for.

It might safely be said that nowhere within 50 miles, and possibly not within 100 miles of New York City, can a large storage of potable water be obtained at so little cost per million gallons as would be the case from storage on Pompton Plains. The available storage by the Mountain View dam from a drainage area of 380 square miles, reserving sufficient capacity in the reservoir for flood control, would still be in the neighborhood of 60 billion gallons. Comparing this with the Pequannock supply for the city of Newark, the drainage area is about six times as great and the capacity slightly more than six times that of the storage reservoirs in the Pequannock watershed. The yield from the Pequannock has been carefully measured, and with its present storage is sufficient for a yield of 50 million gallons per day. If the same ratio of yield is applied to the Pompton Plains reservoir it will give a total yield of 300 million gallons per day. The storage reservoir in the Pompton Plains scheme, being at the lower end of the watershed, would give a more complete development and a higher yield than is the case on the Pequannock. It is, therefore, safe to say that the yield at Mountain View, even with the diversion of the Pequannock, which is in the same watershed, would still be sufficient to give 280 million gallons per day, and possibly as high as 300 million gallons for the driest year. And if 80 million gallons of this development were al-

lowed to discharge down the Passaic River, which would be augmented by the natural flow of the waters of the West branch, the low flow of the Passaic at Little Falls and at Great Falls would be increased above its present flow, and there would still be left for sale or actual diversion from the Mountain View development 200 million gallons of water per day. If this could be obtained for the total cost of six million dollars, the cost of obtaining the same would be \$30,000 per million gallons for the Pompton Plains storage as against the cost of about \$80,000 per million gallons for 50 million gallon development on the Pequannock, which is considered to be an exceedingly reasonable cost. For the new supply for New York City this relative cost will be \$200,000 per million gallons developed, and for the new supply for Jersey City it approximates \$100,000 for its 50 million gallon per day development.

The essential factor to make an immediate development or conservation of water on the Passaic River self-sustaining is to at once procure a customer for the water which can be so cheaply stored. And since the cities of New Jersey in this vicinity are now supplied, but since their needs will gradually increase, if a customer can at once be found outside of these cities, it would be essential that such customer should only be supplied, for a limited time and at a decreasing quantity. These conditions are exactly met by the present situation in regard to New York City's water supply. On page 15 of the report, by Mr. James H. Fuertes, C. E. to the Committee on Water Supply of the Merchants' Association of New York, on water waste, will be found, among other conclusions, the following:

"With the greatest amount of waste and leak reduction possible of practical accomplishment during the coming years, and with the construction of the proposed Cross River Reservoir and all other emergency reservoirs that can be built in the Croton watershed, the city will not be out of danger of a water famine until the new supply is made available. The construction of the first installment of the new works should therefore be started immediately and should be pushed to completion as rapidly as possible."

It is also true, as shown in other reports on the water situation in New York City, that the present draft on their available reservoirs is now from 40 to 50 million gallons per day above the maximum yield of their watershed developments, based on recent dry years. This deficiency will rapidly increase, and unless stringent measures are resorted to to reduce the consumption this ratio of increase will approximate 10 million gallons per day per year, so that at the end of five years the deficiency will be in the neighborhood of 100 million gallons per day. It is also variously estimated that no additional water will be available from the new sources of supply for New York City in from six to ten years.

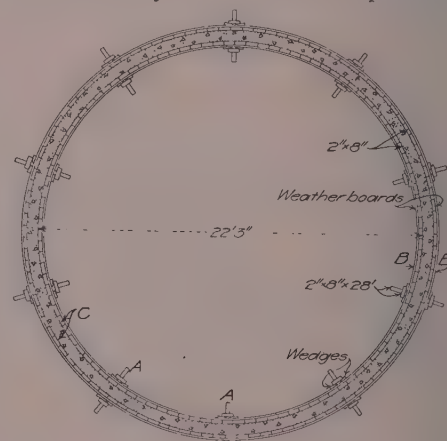
From the above it seems to be a fair deduction that New York City could reasonably afford to pay, as an insurance against a water famine, on the basis of say \$25 per million gallons for an available supply of 100 million gallons per day, which it might demand for immediate delivery. This would amount to over \$900,000 per year, and upon a five per cent. capitalization would seem to justify an expenditure of 18 million dollars.

The reservoir will cost about 6 million dollars to be able to furnish 200 million gallons per day from the same, and it would of course be necessary that some pipe line be constructed to deliver this temporary supply to New York City. This part of the suggested plan has not been worked out in detail, but may be roughly stated as possible of accomplishment for a further expenditure of five million dollars for pipe line, the route of which should be so selected as to make at least three-fourths of its length available for distribution within the New Jersey territory. The con-

struction work in connection with the Pompton Plains scheme is so simple that the works could be built in less than two years.

Summing up the above, an expenditure of 11 million dollars is needed to accomplish flood control and the conservation of at least 200 million gallons of potable water per day, for which it should be possible to obtain an immediate customer for 100 million gallons and an annual revenue of \$900,000 and as the needs of New York City would be supplied by its own works, the cities of New Jersey would become customers of the State. As the prices received from this latter source would, of course, be much higher than that charged for an insurance supply, there would only be a few years intervening between the termination of contract with New York City and the time when the New Jersey cities would be returning an adequate income to pay the interest, sinking fund and cost of operation of the plant. By a proper financing of the scheme, it would seem to be susceptible of the creation of a surplus sinking fund during the early period, supplemented by the increasing earnings in the later period, which would adequately provide for the retirement of bonds issued for the first cost at the end of 35 years, particularly as a portion of the first cost will be provided for by assessments for benefits to be derived from flood control.

The above is presented for consideration and with the expectation that some of its features will be more definitely worked out in the report of the



Details of Reinforced-Concrete Silo Forms.

Passaic River Flood District Commission, which will soon be issued. The writer desires to supplement the foregoing by endorsing the following quotation from a report presented to the Geological Survey of New Jersey, this year, by Mr. C. C. Vermeule, C. E., as follows:

"No proposition to divert water from the State, even temporarily, should be entertained unless the same can be done under the direct control of the State for such a limited time that it will not interfere with the requirements of the cities of New Jersey, and under such conditions that it will not impose a hardship upon the riparian owners along the stream."

While endorsing the above, he begs leave to differ with Mr. Vermeule's conclusion as to the relative availability of the Mountain View site as contrasted with the Little Falls site, which, in the writer's judgment would be less adapted for storage of water for potable purposes.

LIGNITE IN GAS PRODUCERS is reported by Mr. H. Neumann in the "Zeitschrift" of the Society of German Engineers to be giving satisfactory results when the gas is cleaned. For example, at the 250-h.-p. plant of the Kalk Chemical Works a 321-hour test of a 70-h.-p. generator was made, corresponding to a run of 1½ months, and only a very thin soot layer on the exhaust valve resulted, causing no trouble in working. Brown coal briquettes were used.

Cost Notes on a Reinforced-Concrete Silo.

A reinforced-concrete silo built at McLean, Ill., by Messrs. Snow & Palmer, affords some interesting cost data.

The silo is cylindrical in form and its principal dimensions are: Height, including footings, 28 ft.; inside diameter, 22 ft. 3 in.; thickness of wall, 6 in. The footings are carried 2 ft. below the ground level and are 9 in. thick. The total quantity of concrete is 38.2 cu. yd. A wooden roof, conical in form, will protect the ensilage from the weather.

The accompanying sketch shows a horizontal section through the forms. The T-shaped posts, marked *A*, were 20 in number and extended perpendicularly from the ground to a height of 28 ft., being secured at top and bottom by a system of guy ropes and posts. The rings, *BB*, of which there are four, two inside and two outside, were built of weather boards with their edges reversed. Four thicknesses of board were used in each ring. The curbing, marked *C*, was 2x8-in. sticks 4 ft. long. Wedges driven between the vertical posts and the rings held the latter in place. When the forms were to be removed the wedges were knocked out and the rings sprung enough to permit the removal of the curbing.



Reinforced-Concrete Silo.

The rings were then pushed up and fastened in place for another section. The average rate of progress was one 4-ft. section per day. The forms were filled in the afternoon and moved up the following forenoon. Five-foot sections could have been built just as readily.

The reinforcement used in the lower half of the silo consists of ten iron hoops taken from an old wooden silo of the same diameter as the new structure. These are equally spaced and the average section of each is about $2\frac{1}{2} \times \frac{3}{16}$ in. In the upper half one ring of 4-ft. woven fence wire was placed in each section.

The work was done by farm laborers hired by the month. A careful record shows that one hundred man-days of such labor were required. A mason spent seven days at \$3.50 per day brushing and troweling the surface. The concrete was a 1:6 mixture of Portland cement and sandy gravel. The cement cost \$100 and the gravel \$35 on the work. The only new lumber used was the weather boards, which cost \$18. One 20-rod roll of woven fence wire cost \$5.20. Figuring the farm labor at \$1.75 per day and not taking account of the old lumber and hoops used the total cost of the silo was almost \$360, or \$9.42 per cu. yd.

The Engineer-Constructor.

One of the tendencies of engineering procedure which is very noticeable at present is the development of companies acting as designing engineers as well as contractors. Both in Europe and America, bridge companies have long been occupying this dual position upon occasion, but it is only recently that the practice has become common in lines where the main feature of the contract was not some product, like a bridge or a pumping engine, manufactured in one shop. There is a strong opposition to these construction-engineering companies which has been expressed much more often than the argument for them, and consequently attention is called to an explanation of their advantages given before the Electrical Section of the Western Society of Engineers by Mr. George A. Damon, managing engineer of the Arnold Co., of Chicago.

The salient feature of the engineer-constructor is that the term refers to an organization and not an individual. It makes possible the most effective combination of technical theory with practical experience, and provides for the use of team work in connection with the designing and building of properties. Its aim is to attain the greatest economy in effort, time and money. To be most effective such an organization should have at its command the technical knowledge and experience of the past, the ability to analyze situations and discover the truth from conflicting testimony, the imagination to conceive unprecedented results and courage to overcome obstacles, the ambition to improve existing systems and the honesty to spend money without favor or graft, and finally loyalty to itself and to its client, which will protect in every way the interests of all concerned. Such an organization substitutes for the isolated efforts of one or more individuals an effective combination of the aggregate abilities of a number of experts and adds the enthusiasm and inspiration which comes from the contact of fellow workers. There are needed a civil engineer, electrical engineer, mechanical engineer, structural engineer, sanitary engineer, chemical engineer, gas engineer, fire protection engineer, hydraulic engineer, mining engineer, architect, industrial expert, statistician, purchasing agent, construction superintendent, operating engineer, accountant.

Such an organization should not be the maker or manufacturer of any equipment, nor be connected with the exploitation of any system of apparatus, nor interested in the introduction of any patented devices. In its highest development it will be connected only in a technical way with the financial interests controlling the enterprise.

Granted that such an organization of technically trained men can be brought together, what are some of the things which they may be called upon to do? A few of the things requiring such ability and experience in design and construction which first suggest themselves are as follows: Complete steam railroads; complete electric railroads; electrification of steam roads; hydro-electric plants; transmission systems; power plants; gas works; electric lighting systems; industrial establishments; buildings for all purposes; public service works. In so far as an organization is prepared to carry out any of these enterprises effectively, just that far will it reach its highest development.

The carrying out of every big enterprise will entail nearly all of the following duties: Investigations and reconnaissance; preparation of preliminary reports; estimates of costs; estimates of probable earnings and operating expenses; surveys; preparation of plans and specifications; getting proposals and purchasing; letting contracts; field engineering; construction and erection; inspection; preparation of progress reports; record of costs; tests; operations; final reports and statistics; accounting.

Let us take, for instance, the design and construction of a steam railroad locomotive repair shop, involving the expenditure of from \$2,000,000 to \$3,000,000. In deciding on our men, we will make a study of the qualifications of each one, and at the same time we must have a clear conception of the work each one must be familiar with in order that there be no weak spots or break in the organization. The selection of men with their chief duties will be as follows:

Industrial Expert—Designing layout of shops, planning method of handling work and arrangement of tool and transportation equipment.

Electrical Engineer—Providing power and lighting equipment, laying out transmission systems and planning telephone and signal systems.

Mechanical Engineer—Design of power plant, plan of heating and ventilating and laying out air, gas and steam systems.

Structural Engineer—Building foundations, designing steel structures, in charge of reinforced concrete construction.

Architect—Designing building superstructure, choice of fixtures, laying out landscape work.

Civil Engineer—Directing grading, testing of soil, construction of track.

Sanitary Engineer—Design of sewage system, construction of water works, choice of plumbing.

Purchasing Agent—Selecting markets for material, checking bills of material, arranging for delivery of material.

Constructing Superintendent—Organization of construction force, consideration of time element in construction, settling labor difficulties arising in connection with construction work.

Operating Engineer—Consideration of economies in operation, securing reliability in operation, insuring effectiveness in operation.

Accounting Department—Keeping pay rolls, making record of costs, preparing progress reports.

The first work will be a number of preliminary studies, showing the proposed sizes, designs and relative arrangements of the buildings. There will next be forthcoming a carefully prepared report, showing the advantage of the finally selected arrangement, and the suggested construction of each of the buildings, together with a description of the equipment required. An important part of this preliminary report is an approximate estimate of cost, based upon a careful consideration of all the items involved in the construction.

With the general layout and the preliminary report and estimate approved, the next move is to prepare the plans and specifications. To indicate the scope of this work the following illustrative classification is shown, the numbers being the key which is placed in each drawing, specification, data sheet, report, or letter which may be originated as the work progresses:

CLASSIFICATION FOR BATTLE CREEK (MICH.) SHOPS, GRAND TRUNK RAILWAY SYSTEM.

Contract No. 74.

GENERAL INDEX.

Sections of Classification.

74000—Organization.	74600—General equipment.
74100—Building structures.	74700—Power plant equip.
74440—Track.	74800—Tool equipment.

Parts of the Work.

A—Yard.	L—Truck shop.
B—Power house.	M—Coach and paint shop.
C—Storehouse.	N—Freight car shop.
D—Oil house.	O—Planing mill.
E—Office building.	Q—Dry kiln.
F—Locomotive shop.	R—Scrap platforms, sheds, etc.
G—Forge shop.	
H—Iron foundry.	S—Turntables.
I—Pattern shop.	T—Yard crane.
J—Frog shop.	U—Pipe tunnel.
K—Car machine shop.	

Detail Classification.

74000—ORGANIZATION.
74001—Contract.
74002—Home office fixed charges.
74003—Legal expense.
74004—Preliminary reports.
74005—Surveys.
74006—Engineering.
74007—Accounting.
74008—Construction Tools.
74009—Construction office supplies.
74010—Temporary construction.
74011—General construction labor.
74012—Superintendence.
74013—Insurance.

74014—Traveling and living expenses of representatives.
 74015—Tests.
 74016—Preliminary operation.
 74100—BUILDING STRUCTURES.
 74101—Preparation of site.
 74102—Excavation and fill.
 74103—Piling.
 74104—Foundations.
 74105—Superstructure masonry.
 74106—Structural steel and iron work.
 74107—Carpenter work.
 74108—Mill work.
 74109—Roofing.
 74110—Sheet metal work.
 74111—Plastering.
 74112—Painting and glazing.
 74400—TRACKS.
 74401—Preparation of right of way.
 74402—Grading.
 74403—Tie and Track laying.
 74404—Switches and special work.
 74405—Ballasting.
 74406—Fencing.
 74407—Cattle guards, crossings, signs, etc.
 74408—Bonding.
 74600—GENERAL EQUIPMENT.
 74601—Drainage system.
 74602—Plumbing and lockers.
 74603—Water system.
 74604—Heating system.
 74605—Piping system (except for heating system).
 74606—Lighting system.
 74607—Power system.
 74608—Telephone and signal systems.
 74609—Transportation systems:
 Transfer tables.
 Turntables (large).
 Yard cranes.
 74700—POWER PLANT EQUIPMENT.
 74701—Machinery foundations.
 74702—Coal and ash handling apparatus.
 74703—Grates and stokers.
 74704—Boilers and settings.
 74705—Breeching and connections.
 74706—Stacks and draft equipment.
 74707—Heaters, superheaters and economizers.
 74708—Water softening plant.
 74709—Pumps.
 74710—Air compressors.
 74711—Engines.
 74712—Condensers.
 74713—Piping and covering.
 74714—Generators, compensators, transformers and exciters.
 74715—Switchboard and generator leads.
 74800—TOOL EQUIPMENT.
 74801—Line shafting and all shafting and motor supports.
 74802—Forge shop blast and exhaust ducts.
 74803—Individual cranes and hoists.
 74804—Traveling cranes.
 74805—Work benches and material racks.
 74806—Fire protection apparatus (except piping).
 74807—Foundations for machine tools.
 74808—Machine tools.
 74809—Erection of machine tools, countershafts, etc.
 74810—Planing mill shavings exhaust system.

In purchasing, the engineer-constructor should find some advantage over an occasional buyer. He is in the market constantly, is favorably known by the manufacturers of standard equipment, and buys apparatus delivered f.o.b. cars, doing all erection work as far as possible with his own experts, and calling on the factory for assistance only when necessary. There should be the greatest unity between the engineering, the purchasing and the construction department. It is always better to have the construction superintendent in the office while preliminary decisions are being made and bills of material prepared.

Throughout the entire progress of the work systems are in use to keep all concerned informed as to each move. The construction office is advised by the home office as to the material ordered and as to the probable delivery of this material. The home office is advised as to the receipt of material on the job, as well as to the progress of the construction work, and any reports and advice as to the labor situation. To accomplish the former copies of contracts for apparatus and orders for material are sent to the superintendent in charge of construction. Such reports and orders contain exact information as to the material covered by them, as well as to the time at which this material is expected to arrive on the work. A card system in which are entered all orders and contracts is used in the home office, and is designed to follow up and secure prompt delivery of all material and apparatus. In case of any changes in time of delivery of material, the construction superintendent is advised in advance, and is thus in position to make any alterations necessary in his programme. The importance of promptly delivering the material on the job cannot be overestimated, and the value of a system that will provide for the delivery of the materials in accordance with an approximate schedule previously arranged for will appeal to all interested in construction work.

Records of all material received on the job are kept by the superintendent in the form of a material report. These reports are written out in a duplicate book as each shipment is received, and one copy is sent without delay to the main office. This serves to keep the home office very closely in touch with the field work, so far as the receipt of material is concerned.

In construction work consisting of a great many items, such as will be found in railroad shops, it is very desirable to know with a fair degree of accuracy the exact progress of the work. Certain lines of the work, such as the delivery and installation of machinery, are dependent upon the progress of other work, such as the completion of the buildings and foundations. In order that this information may be always at hand, progress reports from the work are received at stated intervals, usually two weeks apart, giving in detail the progress of the work under each classification head. This information is kept in form for convenient reference, and is useful in a variety of ways. Not only do these reports keep the engineering force in touch with the progress of the work, making it possible to more efficiently insure the work coming in proper sequence, but they also provide the information necessary to make decisions as to changes in detail, in case such are found necessary after the work has been begun. These progress reports, together with a record of moneys expended for material and labor at any date, give timely information as to the actual cost of the work as compared to the estimated cost. As such reports are made on the work under each classification heading, any variation of the cost from the estimate is at once detected. This is of importance to the constructor who proposes to complete a certain improvement within a definite estimated cost, and to the client's official who may be charged with the responsibility of protecting a definite appropriation.

Wherever it is possible curves or diagrams are used to represent the condition of affairs of which record is to be kept. A chart showing the progress of the work on building construction is easily made, and shows very clearly at a glance the exact condition of the work at any time. At the end of each two weeks' period, the total expense that has been incurred during the two weeks previous is plotted under each classification head, and this area on the chart indicated in such a way as to designate the progress made during the particular period in question. A glance at the chart will show the total amount completed under each classification represented on the chart at the time the last entry was made, as well as indicating the amount of work that was done during the various classifications during each period under consideration.

Moreover, it is at once evident that, during the period of the fifth payroll about 10 per cent. of the work on the engine pits, 20 per cent. of the concrete superstructure, 36 per cent. of the brick work, 15 per cent. of the sills and coping, 40 per cent. of the windows and small doors was completed, and no work was done on the smokejacks and ventilators, none on the roofing and none on the sash operators and foundations. In other words, these progress reports become the graphical history of the job. After having made out the necessary reports covering both the material and the labor that have been used on the work, it is a very simple matter to embody these results in the chart. A copy of this chart is then sent to the main office where it remains until the time for the next report, at which time it is sent back to the job for the additions that have occurred during the period.

Progress photographs are taken of the work at intervals of about two weeks. These show at a glance not only the general progress of the work, but many construction details as well, which are of interest and value. These photographs are of a

standard size, and mounted on cloth so as to be bound in convenient form for reference. All the reports just referred to, viz., the progress reports, charts and diagrams, while very easily obtained and requiring but little work in their preparation, supply a great deal of valuable information, and are of worth far exceeding the trouble and expense contracted in securing them.

Although every facility is provided for keeping the main office and the construction office in close touch, it should not be understood that the engineering is done at arm's length, and that all plans and specifications are devised and completed by an engineering force in the office to be sent down to the construction superintendent on the job for his execution. A competent engineer is in charge of all construction work, and spends a certain amount of time in the field, thus putting him in close touch with the situation, and enabling him to more efficiently direct the detailed engineering work that is done in the main office.

Most of the work is done on the basis of "cost plus a percentage"—that is, the work is done at actual cost, and then the engineer-constructor gets a percentage fee for his services. By such an arrangement the client or purchaser is relieved of the necessity of organizing a technical force of his own, or of employing a number of individual specialists. If the actual construction work is turned over to the engineer-constructor, then the client is relieved of the inconvenience of obtaining proposals and awarding contracts to a large number of separate contractors, with the attendant delays, conflicts and "extras," which even the closest supervision will hardly avoid.

The difference between the "cost plus a percentage" and the "cost plus a fixed sum" plans is not generally understood. If an engineer-constructor is thoroughly trained in drawing plans, has sufficient actual experience to make a reliable estimate, is absolutely honest in all things, and has complete control of a competent construction organization, then the "cost plus a percentage" arrangement is the better; but if the work is planned by an engineer and architect, and the actual building work is turned over to a separate construction organization, thus maintaining the old relationship of engineer and contractor, then the "cost plus a fixed sum" plan, no doubt, has advantages. The "percentage" plans express a shade more of confidence between the client and the builder than the "fixed sum" basis.

If the duties of making a preliminary report, preparing a careful estimate, drawing up the plans and specifications, purchasing the materials, building the structures, erecting the equipment and installing the machinery are turned over to one reliable engineer-constructor organization on a "cost plus a percentage" plan with the privilege to the client of canceling the arrangement at any time if the progress, quality or cost of the work should prove to be unsatisfactory, Mr. Damon cannot conceive of a more effective way of getting results, and it is very probable that much of the important work of the future will be done upon this basis.

CANADIAN AND AMERICAN PAVING BRICK have been put under comparative tests at Toronto, Ont. The cost of Canadian vitrified brick at the lowest ruling prices was 94¼ cents per sq. yd. as compared with 97 cents for the American vitrified block. The standard abrasion test showed, after 1,000 revolutions, a loss of 17.7 per cent. for the Canadian and 11.8 per cent. for the American product. After 2,000 revolutions the losses were: Canadian, 26.2 per cent.; American, 17.6 per cent. In making the tests 110 samples of Canadian and 160 samples of American pavers were used. Out of 41,656 sq. yd. of brick pavement constructed in Toronto in 1905, 10,415 sq. yd. was laid with Canadian vitrified brick and 31,241 sq. yd. with American vitrified block.

Concrete Pressure Pipes.

Although the investigations conducted under the direction of the Reclamation Service at Los Angeles, to determine the availability of reinforced concrete pipe to withstand pressure from within, did not give encouraging results, as explained in this journal on Dec. 9, 1905, the engineers of the Service have not hesitated to construct such conduits. Some of them are unusual pieces of concrete work, novel in both design and method of execution. Others are minor works for what may be called standard purposes, like the pressure pipes at the pumping stations of the Williston project in North Dakota, shown in the accompanying illustrations. At one of these stations there will be two pressure pipes, one $3\frac{3}{4}$ in. in diameter inside, and 900 ft. long, and the second $2\frac{1}{2}$ ft. in diameter and 400 ft. long. At another pumping station there will be a single $3\frac{3}{4}$ -ft. pipe 300 ft. long, and at a third station there will be one of $2\frac{1}{2}$ ft. diameter 600 ft. long. Their details are shown in the diagrams, and are typical of pressure pipes used on other structures.

They are built in complete sections of lengths that can be finished each day, and the work on each section is carried through continuously without any delay in setting forms or placing concrete, so as to avoid any tendency toward the formation of seams or cleavage planes. Wet concrete is used and rammed with bars so as to drive out all air and insure a complete contact of the concrete with every part of the surface of the steel. The sand used on such work is not al-

The Power Plant of the Erie R. R. Shops at Hornell, N. Y.

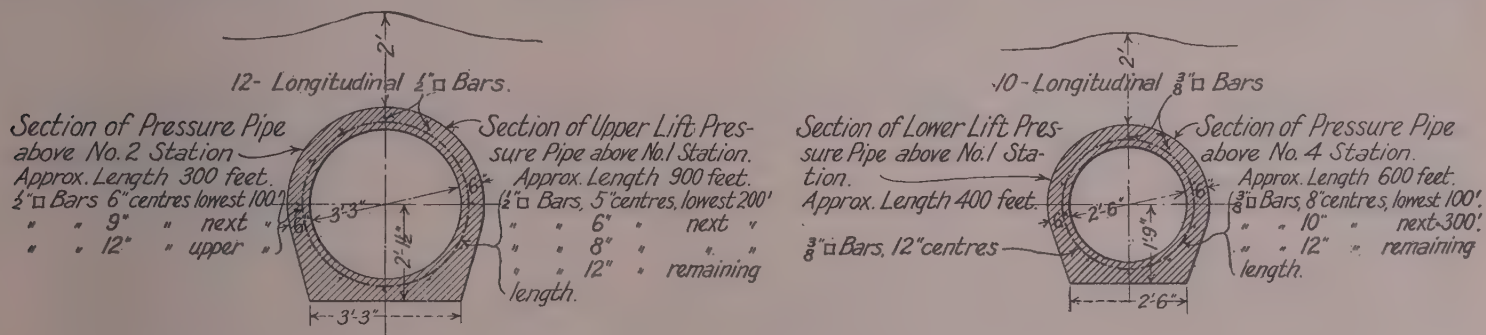
Probably no general class of manufacturing establishments exemplifies the adaptability of electric drive better than railroad shops. The large work handled necessitates extensive buildings and the use of great lengths of shafting and belting if power is transmitted mechanically from a central source. Rush repair jobs are frequent and require a great deal of overtime and Sunday work, when power requirements are small for but sufficient machinery is operated to complete the particular work at hand. Mechanical transmission of power under such conditions is wasteful in the extreme, owing to the surplus power required to overcome the friction of shafting and belting throughout the shops. Where electric drive is used, either individual or group, a flexibility is obtained that cannot be secured by any other means, for it permits the use of a few machines independently, and avoids the objectionable features enumerated, permitting operation with a minimum power house capacity and thereby effecting a considerable saving in fuel.

There are many other considerations in connection with power transmission, one of the most prominent being the layout of the plant, which is particularly important in a railroad shop because it is generally made up of a number of separate buildings aside from the main machine and erecting shops, such as boiler shop, carpenter shop, tank shop, blacksmith shop and pipe shop. These are necessarily scattered, widely distributing the

tem in order to enable them to respond rapidly and efficiently to the increasing demands made by the necessary additions to the rolling equipment.

New shop buildings and round houses have been constructed, old machines replaced by new, an efficient shop organization effected and the entire mechanical department brought up to a high standard of efficiency. This work, under the direction of Mr. E. A. Williams, general mechanical superintendent, and Mr. G. W. Wilden, mechanical superintendent, has been carried on at many different points on the system, but the most extensive single installation of modern shop equipment is at the Hornell shops, located at Hornell, N. Y. At this point new buildings have been erected, additions made to old buildings, a new power-house built and a large number of new machine tools, with a complete system of electric drive, installed. This installation is an interesting and instructive illustration of the latest engineering practice for a railway shop where the largest proportion of power is required at short distances from the power house and a large proportion of variable speed and crane loads are found.

Before making a final decision as to the type of electrical apparatus to be installed, a careful comparison was made relative to the advantages and disadvantages of both the alternating current and direct-current types of apparatus for the service contemplated. This analysis included not only the motors themselves, but also the various accessories, such as wiring and controllers. Due consideration was also given to an installation involving



Pressure Pipes at the Pumping Stations of the Williston Project of the U. S. Reclamation Service.

lowed to carry over 10 per cent. in clay, nor to exceed $\frac{1}{4}$ in. in size, and the voids in it, when it is dried and well shaken, must not exceed 35 per cent. Gravel and broken stone are both permitted, if of satisfactory quality; they are required to be screened between $\frac{1}{4}$ and $2\frac{1}{2}$ -in. sizes. The transverse bars used for the reinforcement are furnished by the Service to the contractor, as a rule, but the latter is required to weld their ends together to form rings. The contractor is expected to produce smooth inside surfaces, on the pressure pipes, by a proper manipulation of the concrete and the use of planed lumber with tight joints for forms. In case there are any cavities left when the forms are removed, these are immediately filled with mortar, after which a coat of cement grout is applied with a brush over the whole exposed surface. Special pains are taken to keep the work well wet until the concrete has hardened, and the outside of the pipes are protected by a covering of earth or other material which is kept saturated with water until the back filling is in place.

A SUCTION GAS-PRODUCER PLANT forms part of the 600-h.-p. municipal electric station of Schwerin, Germany. There are two producers, each with its own evaporator, coke wash tower and wood-shaving, gas-cleaning chamber. A double-seal charging hopper is used, which is filled once an hour. An outer door is then closed and the fuel dropped into the inner shaft, without escape of gas.

power requirements and necessitating the use of a number of prime movers. Where engines are used, steam is supplied either from a central boiler plant or by individual boilers forming a combination unit with the engine. The former arrangement is exceedingly poor from an economical standpoint, owing to the low efficiency resulting from the usual excessive condensation which takes place in long lengths of steam pipe. Either method involves the expense of skilled attendants, which amounts to a considerable sum annually. These conditions are, however, rapidly changing; electric motors are superseding steam equipments and have many times proved that they fill all requirements, reducing operating expenses, requiring a very small amount of attention, providing power that is perfectly reliable, and reducing the time of starting and stopping and changing speed to a minimum. Other applications may be found in cranes and in transfer and turn-tables where the electric motor is superior to every other motive power, owing to its ease of control, efficiency and reliability.

It was these considerations that led the Erie Railroad Co. to abandon mechanical transmission of power and adopt the electric drive at its Hornell shops, which now utilize electric power entirely and furnish good examples of both individual and group drive. When the present management took charge of the Erie R. R. it adopted comprehensive plans for the development of the entire property, which included extensive alterations and additions to the many shops of the sys-

tem in order to enable them to respond rapidly and efficiently to the increasing demands made by the necessary additions to the rolling equipment. While it appeared probable that at some time in the future an equipment of this nature might be necessary, it was decided that present conditions do not justify the installation of both types of motors. Under the conditions existing at Hornell it was considered that all motors are located well within the limits of 220-volt distribution, and in addition there is at this time no wood-working shop with its large requirements for current. Therefore it was finally resolved to make the installation consist entirely of direct-current apparatus with the exception of a small generator set to supply the current necessary for the present yard and depot lights.

As indicated above, the enlargement of the power house at some future time has not only been contemplated, but provided for. The type of apparatus to be placed in the engine room, however, will be determined upon at the time of making the addition, as the present system can readily be expanded in either of two ways. Additional power can be obtained by the installation of the necessary capacity, either in an alternating current generator which will supply the lines direct, the present motor generator set acting as a tie between the present units and the future one, or a direct-current generator with the necessary transforming apparatus for alternating current can be installed if it is found that conditions demand that this be done.

The power house is a large brick structure of fire-proof construction, with concrete roof and

flooring, and has ample provision for light and ventilation. The building is large enough to provide for future extensions, foundations already being in place for doubling the boiler capacity so that it is only necessary to erect the additional units. The boiler plant consists of four Babcock & Wilcox units of 400-h.-p., operating at 150 lb. pressure and equipped with chain grates. All live steam mains are provided with the Holley drip system. The coal handling and stoking are especially interesting as, from the time the coal is dumped from the cars until it is fed into the furnace, it is conveyed automatically. The coal passes from the car into a chute which empties into a crusher and is then conveyed by an endless belt to the top of the power house, where it passes through another chute to the second conveyor which distributes it in the bunkers over the boiler room. Thence the coal passes through chutes to hoppers in front of the furnaces, where it is fed into the chain grates. The amount of coal admitted into the hoppers is controlled in the boiler room by means of levers. The conveyors, which were manufactured by the Exeter Machine Co., have a capacity of 60 tons per hour and are operated by a 10-h.-p. and a 13½-h.-p. Westinghouse type S motor. The coal crusher is operated by a 20-h.-p. type S motor.

The generating equipment consists of three Ball & Wood cross-compound, high-speed condensing engines, two of 500-h.-p. each, direct-connected to a Westinghouse 300-kw., direct-current, 250-volt, three-wire generator running at 150 r. p. m., and one of 400-h.-p. direct-connected to a similar generator of 200-kw. capacity operating at 200 r. p. m. The engines run condensing except in cold weather, when the exhaust steam is utilized in heating the shops. Water for condensing purposes is stored in a large well which derives its supply from a small river near the power house. Besides the generating equipment and pumps there are two Ingersoll-Sergeant compound air compressors that furnish compressed air to the pneumatic hammers in the shops. The Westinghouse motor-generator set which supplies current for the yard and depot lights, consists of a 115-h.-p. type S motor direct-connected to a 75-kw., two-phase, 60-cycle, 1,040-volt revolving field alternator operating at 900 r.p.m.

A standard Westinghouse switchboard is provided with motor-generator panels, direct-current generator panels, feeder panels and a load panel, two blank panels providing for future extensions. There are three motor-generator panels, two alternating-current and one direct-current or motor panel. The alternating-current generator panel is provided with one indicating wattmeter, one ammeter, one voltmeter, one type F oil switch, a rheostat, and the usual smaller instruments. The feeder panel is equipped with one power factor meter and two type F oil switches. Mounted upon the motor panel is a circuit breaker, an ammeter, a field rheostat and a motor-starting switch. The three generator panels are provided with the usual apparatus for a three-wire installation. The load panel is equipped with two switchboard type integrating wattmeters, two ammeters and two voltmeters.

The six feeder panels control six circuits as follows: Circuit 1, new erecting shop, 120-ton crane and transfer table; circuit 2, carpenter shop, blacksmith shop, new boiler shop and tank shop motors; circuit 3, round house turn-table, machine shop, coal pocket and ash-pit motors; circuit 4, all line shaft motors; circuit 5, individual drive motors; circuit 6, motors in power house for coal-conveying apparatus. Each feeder panel is also provided with switches for controlling the various lighting circuits.

Current is transmitted by cables through a large tunnel to the new erecting shop and thence through underground conduits to the various buildings. The Westinghouse three-wire system

of distribution is used for lighting and power, with an electro-motive force of 250 volts between outside wires and 125 volts between each outside wire and neutral. There is a decided advantage in the flexibility of the voltage, as incandescent and Cooper-Hewitt lamps are operated on the 125-volt sides of the system and constant-speed, 250-volt motors are connected to the main or outside wires, while the variable speed motors utilize shunt field control.

The old erecting shop utilizes both group and individual drive, the group-driven machines being divided into five sections and operated by five type S constant-speed motors, two of 30-h.-p. capacity and three of 50-h.-p. capacity. The machines in the fitting shop, which occupies one wing of the erecting shop, are also group driven by a Westinghouse 30-h.-p., constant speed, type S motor. In addition to the group-driven machines in the erecting shop, there are a number of individually driven machines operated by both constant and variable speed type S motors, the latter ranging from 7½ to 40-h.-p. in capacity. The speed of these motors is controlled by varying the field strength, and, as this may be done while the machine is in operation, it affords an easy and convenient method of speed regulation always under the immediate control of the operator, the controller being conveniently placed within his reach. The variation of field strength is effected by means of a resistance placed in the shunt field circuit of the motor, which decreases the shunt field current and causes a decrease in the field strength and an increase in speed.

One of the characteristics of this method of control on which stress is laid by the designers of the installation is the simplicity and low cost of control apparatus made possible by the extremely small current handled. A second characteristic on which they laid stress is the increase of speed with decrease of torque, when used as an adjustable speed motor, the horse-power output remaining practically constant throughout the whole speed range, which makes it peculiarly adapted to machine tool driving. This system involves the use of a minimum amount of auxiliary apparatus, thus materially reducing the first cost of an installation. The regulation of motors operating by shunt field control is good, which is of special importance in the operation of machine tools and in service of any class where constant speed is desirable and where the torque varies between wide limits. The efficiency of the motors operating at variable speeds remains practically constant over the range of speed.

The electrical equipment for the other departments is as follows: In the tool room a 20-h.-p. constant speed type S motor is used, in the carpenter shop a 50-h.-p. constant speed motor of the same type, and in the blacksmith shop a 30-h.-p. constant motor. The boiler shop has a 7½-h.-p. constant speed motor for the flue-welding and flue-cutting machines and direct-connected constant speed motors for the large tools. In connection with this shop there is also a 4x22-ft. flue rattler driven by a 20-h.-p. motor; this rattler cleans an average of five lots of tubes, from 175 to 200 tubes in each lot, in a day. In the tank shop there is a 20-h.-p. constant speed motor driving punching and shearing machines, and two direct-connected constant speed motors of 10 and 15-h.-p. respectively, geared to a plate roll. In the round-house machine shop a variety of tools are driven by a 20-h.-p. constant-speed motor. The miscellaneous uses of electricity about the works call for a 70-h.-p. constant-speed motor for driving the fan of the heating system of the round-house, a 10-h.-p. constant-speed motor for the fan of the heating system in the new erecting shop, a 7½-h.-p. variable-speed motor for the round-house turn-table, a 50-h.-p. constant-speed motor for the coal conveyor in the locomotive coaling station, a 30-h.-p. constant-speed motor for the ash conveyor

which removes ashes from the locomotive ash-pit, a 7½-h.-p. motor operating alligator shears for cutting up scrap iron, and a 25-h.-p. motor operating the transfer table.

The preliminary studies and final report, showing the benefits which would be the result of electrically equipping these shops, were made by the Westinghouse Electric & Mfg. Co., in conjunction with the Motive Power Department of the Erie. The results are stated to have more than borne out the promises made to the management. The work of transformation was carried on without any interruption to the service by the contractors, Westinghouse, Church, Kerr & Co., who installed the plant, and Mr. George T. Depue, master mechanic of the Erie Railroad Co., who has charge of the Hornell shops.

Sinking Pneumatic Caisson Foundation Piers with Upward Reactions.

A steel cage building now being erected at Nos. 30 and 32 West 21st St., New York, occupies the whole of a 40x100-ft. lot between two five-story brownstone front residences of the type so numerous in that part of the city. Their brick side walls were carried on rubble masonry footings seated on fine sand, resembling quicksand, at ground-water level about 12 ft. below the curb, and from 10 to 25 ft. above bed rock. After the old building was demolished, the full area of the lot was excavated down to about the level of the adjacent footings, and both adjacent walls of the neighboring buildings were supported on wooden needle-beams about 5 or 6 ft. apart, passing through holes cut in the brickwork above the stone footings. The inner ends of the needle-beams rested directly on timber sills, parallel with the walls, distributing the loads on the basement floors. The outer ends were supported by jack screws from similar continuous sills laid on the bottom of the general excavation.

The wall columns of the new building are to be erected on twenty-four 4x6-ft. concrete piers carried down to rock. In order to serve both as supports for the new structure and to carry the walls of the adjacent old buildings, the piers were located concentric with the columns of the new building, thus bringing about one-third of the area of each pier outside the building line. The tops of the piers are capped with granite coping on which lines of I-beams are placed in the planes of the walls to carry the brickwork across the clear spaces between the piers. The walls of the adjacent buildings are each about 75 ft. long and additional I-beams are placed under them to carry them as well as the new walls.

The construction of the piers was commenced in open sheeted pits which were carried down to rock with considerable pumping, and the concrete was successfully built in twenty of them. The remaining four piers at one corner of the lot and partly under the adjacent wall, were located in quicksand so deep that it became impossible to build them by this process on account of the difficulty in pumping and the flow of the quicksand into the pits. A contract was therefore awarded to Mr. Thomas B. Bryson, contracting engineer, 60 Wall St., New York, who continued the work from the point where it was left by the original contractor and successfully built the piers by the pneumatic caisson process combined with the Breuchaud method of utilizing the weight of the superstructure for reactions, in sinking caissons.

Wherever a needle-beam was so located as to interfere with the position of a caisson, the outer end of it was supported on a secondary longitudinal sill parallel to the wall and close to it with its ends supported on two adjacent needle-beams, thus leaving an unobstructed working space in front of the pier and supporting the wall over it.

The lower 8-ft. sections of the caissons included a 6-ft. working chamber and 2 ft. of the lower part of the cofferdam built in a single continuous unit. They were made entirely of wood of simple construction with 3-in. calked vertical outside planking fastened to top and bottom inside horizontal rectangular frames and decked with two crossed layers of planed and calked 3-in. planks. They were delivered complete to the site and skidded and jacked to position by hand.

Two 5-ft. lengths of cylindrical steel air shafts 3 ft. in diameter were bolted to the top of the deck and were fitted with top and bottom doors making an air lock. The masonry footing and enough of the lower part of the brick wall were cut out over the caisson to allow one 25-ton jack screw to be placed on each side in the plane of the brick wall and bearing against the latter through a horizontal cap timber. A few tons of pig-iron ballast was placed around the air lock on the roof of the caisson and the excavation was carried on by two men, who filled the earth and quicksand into canvas bags which were hoisted by hand through the air lock.

The caisson was readily forced down by the two jack screws reacting against the wall, which had an estimated weight of 15,000 lb. per linear foot, and as fast as it descended, blocking was packed in above the jacks until sufficient space

The New Orleans Railway Bridge.—II.

By Elmer L. Corthell, Director and Chief Engineer, Southern Bridge & Railway Co.

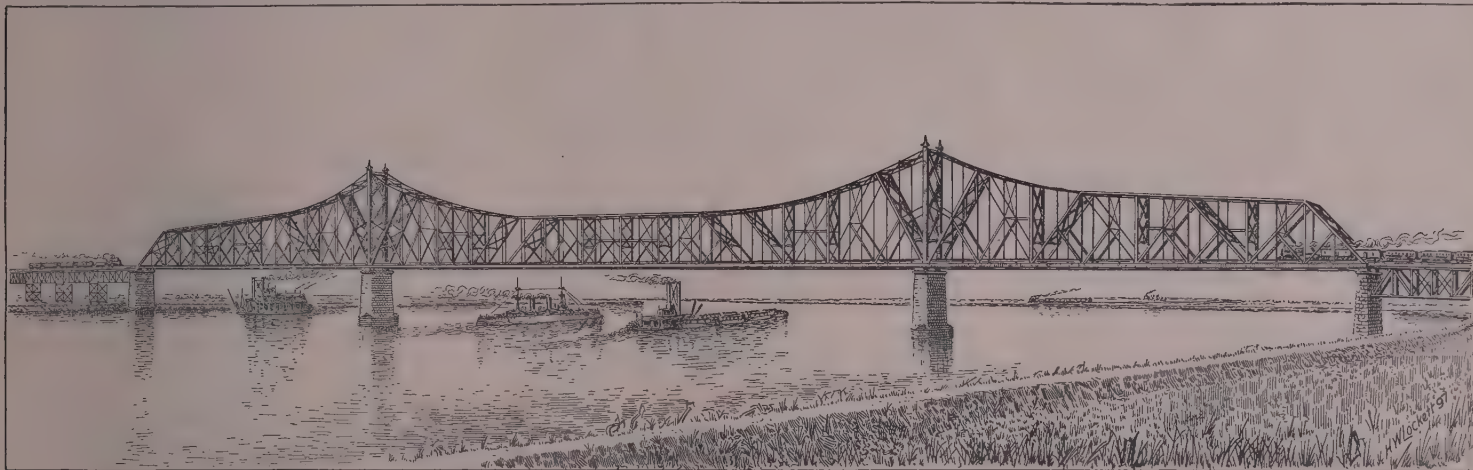
The plans of the bridge, especially the superstructure, have had several years of study. These were under the direct supervision of the writer's associate, Mr. E. H. Connor, now chief engineer of the Missouri Valley Bridge & Iron Co., Leavenworth, Kan. Several alternative designs were fully worked out from the strain sheets to the details of steel work, ready for the shop drawings. The approved plan provided for a bridge of a total length of 2,280 ft. The two anchorage spans of the cantilever structure are 606 ft. 8 in. long, and the central span is 1,066 ft. 8 in. The height of the anchorage span at the shore end is 72 ft., that of the central posts over the river piers is 160 ft. The suspended span between the cantilever arms is 73 ft. 4 in. high, and 440 ft. long. The width between trusses throughout the bridge from center to center is 40 ft. There is a stiff bottom chord the entire length of the structure, stiff diagonals, and, where connections are required, stiff hangers at secondary panel points. The entire superstructure of the main bridge will weigh 23,700,000 lb.

Medium steel having an ultimate strength of 64,000 to 72,000 lb. per square inch is used in

of timber and 15,300 cu. yd. of concrete. The lower edges are protected by heavy steel shoes sufficient to cut through any timber obstruction that may be encountered by sinking, though such obstacles are not likely to be met with in this stretch of river. The total fatigue weight on the foundation material will exceed but slightly 6,000 lb. per square foot. The foundation will be protected from scour by willow mattresses, covered with rip rap stone. The shore piers will be rested on pneumatic caissons sunk 100 ft. below low water. The total height of the structure at the river piers from base of caissons to the top of the ornamental work on the vertical truss posts is 450 ft.

Each approach has one pin span 150 ft. long and 10 pin spans of 120 ft. and 28 60-ft. plate girder spans, making the total length of the entire structure 10,634 ft., a little over two miles. The approach spans are supported on steel towers resting on circular brick piers with granite caps, concrete bases and pile foundation. The remainder of the approaches consists of timber trestle 1,400 ft. on each side and earth embankments. The timber trestle will be filled later.

A complete description, specifications and a detail schedule of units of work for tenders were prepared and competitive bids were received. The bid of the Phoenix Bridge Co. was the lowest,



Proposed Double-Track Railroad Bridge over Mississippi River above New Orleans, La.

was provided for the insertion of a 5-ft. section of the wooden cofferdam, built like the caisson. Each caisson was sunk to rock at a depth from 30 to 37 ft. below the curb in three to five days, with two men in the working chamber and two lock tenders.

A maximum air pressure of 10 lb. was provided by an Ingersoll-Sergeant compressor operated by a Westinghouse electric motor. The working chambers were filled under pressure with 1:3:5 concrete made with Atlas Portland cement. After it had set, the air locks were removed and the cofferdams filled with the same concrete up to the granite cap stones, 2 ft. clear of the brickwork. The site was so much obstructed by the needle-beams and bracing in the excavation, that there was no clearance for derricks and all of the work was done by hand.

A building at Nos. 14 and 16 West 17th St., and the conditions obtaining there, correspond precisely with those above described, and three of the twenty-four caissons at that site were built in the same manner as were the four on 21st St.

Messrs. Buchman & Fox are the architects for both buildings.

SCREW SPIKES are being tried on the Pennsylvania R. R. A threaded hole is bored in the tie for each spike and a steel helix threaded in it. The spike is then screwed in and its thread cuts into the wood between the steel helix. Flat tie plates without claws and 100-lb. rails are used.

the calculations. If a steel with an ultimate 20 per cent. greater were used for the main truss members of the cantilever arms and anchorage spans near the river piers, where the dead load stresses are enormous, a higher stress could be permitted and the members made lighter.

The bridge is designed for a double track, the clear height being 85 ft. above extreme high water, which is about 20 ft. above low water; the rail of the bridge is about 100 ft. above the land on either side, which requires approaches 6,580 ft. long with a grade 1.5 per cent. The total distance between rail connections on each side of the river is 6½ miles. Large assorting yards are provided near the end of the bridge approaches.

The bridge structure will rest in the alluvion of the river. Borings to a depth of 1,000 ft. in the city of New Orleans encountered nothing but loam, sand and some thin strata of clay. The material at the bridge site is sand, growing coarser as the depth increases.

The river piers will be rectangular with projecting starlings at the upper ends from the base to high water. They are 30 ft. x 97 ft. over all at the base, and 18 x 54 ft. under the top coping. They are 126 ft. high and there are 6,600 cu. yd. of masonry in each pier. They rest on timber caissons, 60½ x 126½ ft. at the base and 140 ft. high. These caissons have open wells for dredging and closed pockets to be filled with concrete, and all are to be sunk by dredging to a depth of 70 ft. below the river bed, or 170 ft. below low water. Each caisson contains 4,500 M ft. B. M.

\$4,463,464.50, to which should be added the cost of work outside of the proposition amounting to \$858,360. This embraces all possible items, including engineering and superintendence, general management, right of way, incidental and legal expenses, etc.

Assuming three years as the time for doing the work and allowing for the interest during the construction, the total cost exclusive of operating plant and equipment will be \$5,698,824.50; say, to cover all contingencies, increase in price of material, etc., \$6,000,000. The cost of assorting yards, plant in the way of shops, offices and accessories and the equipment, all sufficient for the bridge company to handle the traffic between connected points on each side is about \$600,000.

There is nothing problematical about the project so far as the construction is concerned, and as to the financial conditions a careful investigation shows that the bridge will easily earn 5 per cent. on over \$13,600,000, and assuming the same rate for freight cars and passengers as are carried on other large Mississippi and Ohio River bridges. It is unnecessary to go into the details of the earnings and income, but they have been most carefully investigated.

As will be easily understood there is an objection to a high bridge at New Orleans where the rail level is 100 ft. above the land, requiring a long heavy grade to surmount the elevation, although this is not much more serious than the grade of the Cairo bridge or the western approach of the Memphis bridge. Still if a plan could be

devised to erect a bridge without this grade it would be looked upon with more favor by the railroad interests. In fact the suggestion of Captain Hutchinson that it was worth the attempt to devise a low bridge plan that would be accepted by Congress and the river interests led the Phoenix Bridge Co. to work out a design for a great double draw bridge, each draw to be over 1,000 ft. long, making a central opening over 1,000 ft. in the clear, both draws swinging or opening downstream, thus virtually opening the whole river with a clearance high as the heavens. Messrs. Waddell & Hedrick, assisted by Mr. Montgomery Waddell, also asked the privilege of working out a bascule plan that would meet the conditions.

The objection to the bascule plan are that the requirements of Congress as to length of central span are not complied with, the clear length being only 750 ft. The other objection is that the group of four cylinders constituting each of the river piers occupy a great width of the river section, and it will be necessary to brace these columns together under water. The cost, however, even allowing for the capitalization of operating expenses is less than that of the other plans.

The comparative costs as worked out by the Phoenix Bridge Co., with capitalizing of operating expenses for double draw and bascule at 5 per cent., are as follows: Original cantilever, \$4,946,471; double draw span, \$4,796,550; modified cantilever, \$4,856,371; bascule, \$4,107,950.

In reference to the drawbridge plan it may be stated that the designers are confident of entire success in operating it. The upstream movement of the steamboats at the bridge site is along the left bank of the river in slack water and they would pass through the 500-ft. span, it swinging away from them. The downstream movement of the steamboats either by themselves or with fleets of barges, is in the central part of the river where they would pass through the 1,000-ft. span. There would be built above and below each draw pier a substantial protection. Connected with it and the draw pier will be a timber guard, which will have a total length of 1,100 ft., say four or five boat lengths, which will make the passage through any of the three openings entirely easy and safe for boats or tows of barges.

The General Electric Co. worked out plans and estimates for handling these immense draws and they have made satisfactory plans of all the power and machinery required.

As to the bascule plan, outside of the objections above referred to, there appears to be no reason why it would not work satisfactorily, and Messrs. Waddell & Hedrick deserve great credit for the solution of the difficult problem by this clever application, on a large scale, of the old and successful bascule method. These alternative plans were brought out in March, 1890, only a few weeks before the writer was obliged to leave for Argentina on a two-years' contract with the Argentine government as its consulting engineer. The pressing and responsible duties of this position and his absence in a distant country, prevented his giving any further attention to a matter that was not ready for consummation. In the meantime and before his return to this country, Mr. Huntington died and his great interests passed into other hands, which have not as yet revived the project. The writer has, however, preserved the plans and all the documents, notebook of surveys, etc., in readiness for taking up the project whenever it is ready for realization.

As to New Orleans as a location of the bridge over the Mississippi River and the necessity constantly increasing for such a bridge, there will be but one opinion if the geographical and general commercial and traffic conditions are carefully considered. First, as to the necessity of some bridge across the lower Mississippi. There are now two bridges over the river between St. Louis and New Orleans; one at Thebes, Ill., and

one at Memphis, Tenn. Without some relief is given to the crossing conditions at New Orleans in the near future, it is probable that the traffic movement between the East and the West on the southern lines will be diverted to these northern crossings, as commerce always, other things being equal, moves on lines of least resistance. Between Memphis and New Orleans, a distance of 721 miles by river, there is no crossing for railroads except by transfer boats, and yet, converging upon the two banks of the river at New Orleans, are great systems of railroads, including the "Frisco" lines, 20,000 miles in extent, reaching to Louisville, Cincinnati, the Great Lakes and the Pacific Coast. Mr. E. T. Jeffrey as long ago as 1888 stated the following in an address before the City Council of New Orleans:

"Take the great metropolis of New York, Boston with all its wealth, learning and great railway systems, Philadelphia or Baltimore, and singular as it may seem, not one of these cities has a system of railways so comprehensive and far reaching as the systems resting in this city. I will go farther than this, and say that no other city in the world—and this may seem like a broad assertion—through its systems of railway covers directly and without use of systems reaching rival cities, so vast an area of productive territory. The most fertile region in the world, the greatest agricultural and mineral (and I had almost said industrial, but we have scarcely arrived at that stage yet) region in the world, is this great broad valley extending from the Alleghenies to the Rockies, and from the head waters of the Mississippi and the great lakes to the Gulf of Mexico. And that whole, vast, fertile area, is not only drained by the river running past your doors, but every part of it is reached directly by the systems of railway which rest here within your city limits."

With conditions of this kind, which since 1888 have greatly enlarged as to the general commercial business of New Orleans, it would seem folly to go to a location at Baton Rouge, 85 miles further up the river, or seek any other point where there are no terminals whatever at present and where great systems do not come together for an interchange of traffic, and where they do not even reach. The Southern Pacific system has a natural terminal at New Orleans. It could not reach Baton Rouge except by building 50 miles of line across the lowlands of Louisiana, crossing the Atchafalaya—one-quarter as large as the Mississippi—and numerous other streams and bayous, and then the Mississippi itself, which is as large at Baton Rouge as at New Orleans, and where the only possible advantage to be gained is somewhat higher land on one side than is found at New Orleans, an insignificant advantage when compared with the great cost of the main bridge in either place. Then, again, and perhaps still more important than the above-stated objection to a crossing at Baton Rouge, is the fact that New Orleans is sufficiently far from the sea for an ocean terminal, 110 miles. Very costly terminals of all kinds have been provided there by the railroads at great expense. One system, the 'Frisco, is now building a deep water terminal costing several millions and the Southern Pacific, the Illinois Central and the Texas & Pacific, have terminals of great magnitude and built on modern plans, warehouses, grain elevators, etc. And the same may be said of other railroads reaching New Orleans.

The writer, from 31 years of experience and intimate knowledge of New Orleans as a sea terminal, is of the pronounced opinion, first, that no other point should be thought of for a moment for a bridge over the lower Mississippi River. And second, that it is only a question of time when the insistent demands of commerce, becoming more and more accentuated as the years go by, will make a bridge there an imperative

necessity to the East and West commerce of the United States, and the ocean commerce as well.

Pollution of Shellfish by Sewage.

In July, 1900, a study was begun at the Lawrence Experiment Station of the Massachusetts State Board of Health, of the bacteriological pollution of shellfish. A review of the literature on the subject was published in 1902, but the greater and more interesting part of the information accumulated has been made public in an article by Mr. H. W. Clark, chemist of the Board, published in its thirty-seventh annual report.

In the bacterial work, tests for the presence of *B. coli* in the water in the shellfish and in the body of the fish itself have always been made, and many determinations of other sewage bacteria have also been made, especially of Houston's sewage streptococcus. These tests have been carried out in the usual manner for the determination of these bacteria, and it has been shown by many results that tests for *B. coli* alone might at times be misleading, since the hardier and more quickly growing bacilli in the polluted water surrounding clam flats, and in the water and body of the clam itself, overgrow and kill out *B. coli*.

The shellfish used in the tests were obtained from the flats and beds, from dealers and from restaurants, and in most instances the place and the character of the water in which they grew was known.

In the report the results of the tests are shown in thirty-seven tables. The evidence gathered is fairly conclusive that *B. coli* and streptococcus are not normal inhabitants of the shell water or body of either oysters or clams, and that their presence there must be considered proof of pollution. Of 88 samples of clams gathered from 11 polluted sources, 25, or 28 per cent. only, contained bacteria of the colon type; of 44 samples obtained from 16 sources that may be considered non-polluted, or but slightly polluted, none contained bacteria of the colon type. The same statements hold true in a general way in regard to the shell water of the samples from practically every source included in the above summary, although the shell water is more likely to contain sewage bacteria than is the shellfish itself.

Of the large number of clams examined from many sources, the larger percentage was free from bacteria of the colon type; and the same statement holds true of the oysters examined. A number of lots of oysters were free from bacteria of the type named, judging from the samples examined; but in a number of lots a considerable percentage of the oysters contained *B. coli* and streptococcus, judging from the oysters examined. These oysters must have been from polluted sources, or they were polluted in some manner after being gathered.

The work also shows that *B. coli* and the sewage streptococcus can live upon or in the body of clams and oysters for many days when these shellfish are kept under market conditions; hence immunity from destruction of pollution in this manner cannot be assured.

The cooking experiments with both clams and oysters show that some of the common methods of cooking cannot be depended upon to destroy the bacteria of the sewage type found in shellfish; that is, to do this, a degree of heat or a period of cooking is required in many instances that destroys or impairs the palatability of both oysters and clams. It is, of course, evident that neither should be eaten in the raw condition except from unpolluted and certified sources. It is also evident that, in order that all danger from bacterial pollution may be removed, the sources from which clams and oysters are gathered should be carefully protected from pollution, and that the shellfish from sources known to be polluted should not be allowed to be shipped to market.

Steel Rails.

There is no subject which is receiving more attention from railway engineers at present than that of steel rails. It is unquestionably true that many companies are far from being satisfied with the quality of the rails they receive, and on Nov. 16 Mr. Robert Job, of the Philadelphia & Reading Ry., read a paper before the New York Railroad Club in which he stated a number of reasons for the difficulties encountered. The first of these mentioned was that the same care is not used as formerly in the preparation and cropping of the ingots, while in the rolling much higher finishing temperatures are maintained, resulting in coarser structure with relatively rapid wear. In many cases the composition is better to-day than formerly, yet in spite of what, under present practice, would be considered dangerous composition, the old rails generally gave excellent service, due largely to a thorough working of the steel down to a low finishing temperature. Mr. Job illustrated this point by microphotographs of numerous old and new rails, with accompanying analyses of the metal.

On noting the vast differences in character, the question at once arises, why is not the former close-grained slow-wearing structure produced to-day? Is the change due merely to the insistent efforts of the mills for higher tonnage or do other elements enter into the case? The answer is complex, according to Mr. Job. In the first place the increased weight of the present sections of 90 or 100 lb. per yard instead of 60 or 65 lb. has radically upset the ratio between the various components of the area of the rail, that is, head, web and flange. The former is far thicker and of much greater mass than formerly, while the other parts in many cases have increased but little in thickness or even have decreased. As a result of these changes the flange gets to the lowest temperature at which it can be rolled long before the head reaches the same temperature, so that even though the flange be fine-grained and tough, as fine even as was obtained in the old practice, the crystals of steel in the head may be very coarse, since they were growing in size from the time that pressure upon them in the rolls ceased until the steel at that point had fallen below a dull red heat. This condition would mean relative rapid wear and brittleness.

From the above it is evident that in order to get fine-grained structure clear to center of head two courses are open. First, to rearrange the proportions of the rail in such manner that each component part shall reach the critical temperature at more nearly the same time, as in the old sections, or, secondly, to change the heat treatment given the steel, either during the rolling or subsequently. By the first method the large crystals would be prevented from forming, while by the second, even though formed, they would be broken up by the reheating.

In some of the mills it is common practice to hold the rail before the last pass with the object of giving greater toughness and better wearing qualities to the steel owing to the finishing at a lower temperature. Unluckily the plan is of little benefit, since thereby a fairly fine granular structure is produced to a depth of only about an eighth of an inch from the surface. This, in service, is quickly worn away, exposing the coarse structure beneath.

As an example of the influence of heat treatment after rolling, mention was made of the results of an investigation carried out several years ago under Mr. Job's direction upon the Reading Railway. Eleven 90-lb. rails of coarse granular structure were, through the kindness of the Pennsylvania Steel Co., sawn in halves, and one-half of each run into a reheating furnace, brought to a cherry red, and at once removed and let cool

in the air. In the annealed rails the coarse granular condition was entirely obliterated and replaced by a very fine structure resulting in great toughness. These twenty-two rails were laid in track at Reading at a point where they were subject to slow heavy traffic. All of them were in the same line, laid alternately, first an annealed rail, and then its untreated half. From time to time measurements were made of the contour with a rail indicator. After being subject to a traffic of approximate 88,128,000 tons the annealed rails showed 31.9 per cent. the more rapid wear, while they also showed the greatest tendency to mash down and splinter. The average loss of weight was 2.85 lb. per yard for the untreated rail and 3.77 lb. per yard for those treated. Upon cutting out strips from the heads and subjecting to tensile test the following averages were found:

Nat. Annealed.

Tensile strength, lbs. per sq. in....	129,700	126,100
Elastic limit, lbs. per sq. in.....	80,600	70,225
Elongation, 2 in. section.....	21%	22%

The composition averaged about as follows: Carbon, 0.540 per cent.; phosphorus, 0.079 per cent.; manganese, 1.060 per cent.; sulphur, 0.080 per cent.; silicon, 0.090 per cent.

The clear teaching of the trial was that under heavy traffic high elastic limit is essential to the best service, and it was also evident that if one proposes to get greater toughness and safety by some treatment, like the annealing, which lowers the elastic limit, one should also, to get the best results, increase the carbon or manganese contents to the point at which the elastic limit will be high enough to resist crushing, even though the steel be somewhat unsound. In other words, the toughness and elasticity produced by the fine granular structure permit one to increase the hardening contents considerably beyond the point which otherwise would be safe, thus obtaining greater capacity for wear.

Unfortunately, annealed rails, with their freedom from brittleness and from internal strains, are of hardly more than theoretical interest, since they cannot be obtained in any considerable quantities under present conditions.

It has been Mr. Job's experience that the form of section may yield a decided influence upon the mechanical strength of the rail. To express the matter in another way, with steel of precisely the same composition and degree of porosity one section will tend to support loads better and show greater freedom from crushing and splintering than will another section of the same weight per yard. To illustrate the point he cited an instance which occurred upon the Reading. A considerable extent of track had been laid in 1890 with 90-lb. rails of the then standard P. & R. Section, which had a rather deep head with an angle at the side of head approximating the converse of a wheel flange. These rails gave excellent service for fourteen years, and in order to note the comparative influence of section upon wear a number of them were removed and placed in track, turned, upon an 8-deg. curve, in the same track and adjoining 90-lb. rails of the Am. Soc. C. E. section. Measurements were taken after one year's service, and it was found that the square-headed rail held its angle for only a comparatively short time under heavy traffic. It is also a matter of frequent observation that when porosity of the steel is present, rails of the square-headed type have a much greater tendency to sliver and crush along the outer edge than do rails of the other section, the reason evidently being that the mass of metal supporting the edge is very much less in the former than in the latter.

A good deal of discussion has arisen from time to time concerning the effects consequent upon overloading of rails, and in some instances manufacturers attribute the crushing down and splin-

tering of their product to the heavy wheel loads now prevalent. A lot of 90-lb. Am. Soc. C. E. rails had been furnished upon an absolute guarantee of five years' service, but a considerable number had mashed down completely within six months. The mill made inspection and refused to make replacement, claiming that the condition was simply a result of heavy-wheel loads and other severe conditions for which the mill was not responsible. Etching a section of one of the rails proved beyond all possible contention that the failure was due to unsound steel, and replacement was accordingly made without any further quibbling.

The appearance of the fracture of a rail which has failed owing to overloading is distinctive. It generally takes place immediately over a tie, due, of course, to the repeated straining of the metal beyond its elastic limit. At first, merely a hair crack is found. This, with repeated bending, gradually extends into the rail and the broken surfaces become smooth, and darkened by oxidation, as shown in the figure. Finally, the remaining metal is too slight to support the weight of a passing load, and the final fracture occurs. One of these light rails taken from track and broken under the drop showed one of these typical cracks developing over each tie, proving clearly the need of close watchfulness in the maintenance of track subjected to heavy traffic.

The important question is, How can better rails than are now secured be obtained? Mr. Job's answer is as follows: By modifying the section of the rail a finer granular form with its inherent toughness and tenacity may be obtained. By insisting upon cropping of ingots clear to sound metal, and by testing a rail-butt which is with certainty known to have been taken from the top of an ingot, so that if marked unsoundness be present, the heat may be rejected by the drop test, a reasonable degree of soundness can be secured, and slivering and crushing largely prevented. By increasing the hardness of the rail as much as is compatible with the character of the roadbed, the rate of wear may be decreased, but we believe that further aids are necessary and can before long be obtained. The Bessemer rail has filled an important need, particularly in the days of light, easily rolled sections and light wheel loads. Under present conditions, however, there is urgent demand for harder, tougher steel. In the Bessemer rail the hardness, with the proportion of phosphorus usually present, cannot be increased beyond present practice, say 0.60 or 0.65 per cent. carbon, without causing undue brittleness, and hence advantage has been taken of the basic open hearth process by which phosphorus and sulphur can be nearly eliminated. With these elements of brittleness largely removed the proportion of carbon has been increased safely and with very favorable results to nearly 0.90 per cent., thus securing great hardness, together with great tenacity and a very low rate of wear. Bessemer rails will undoubtedly continue to be used for the lighter sections and in locations where traffic is light, but Mr. Job believes that under the more exacting conditions this quality will before long disappear, replaced by the harder, tougher steel of the basic open hearth process.

THE FUEL CONSUMPTION OF TWO 120-H.P. DIESEL OIL ENGINES, at Effingham, Ill., each direct-connected to two 60-cycle, 2,200-volt, 85-k.w. alternating-current generators, was stated by Mr. W. G. Austin, before the Illinois State Electric Association, to be 15½ gal. of crude oil for a 24-hour run, the load averaging 23 per cent. of full load. Oil costing 3.4 cents per gallon was used, making cost of operation 0.542 cent per kw.-hour. With a 30 per cent. load, the fuel cost decreased to 0.485 cent per kw.-hour, while on a 6-hour test with a 70 per cent. load, it was reduced to 0.384 cent per kw.-hour.

Power and Heat for Office Buildings.

By Charles L. Hubbard, Consulting Engineer, Boston, Mass.

These notes have been prepared especially for the use of architects, and their purpose is to assist them in determining approximately the space to be reserved for the power and heating plant in office buildings.

The method employed is that of presenting simple rules for computing the capacity of boilers, engines, generators, and elevators, from which, by the aid of manufacturers' catalogues and dimension sheets, the architect can closely approximate the form and magnitude of the space required for their accommodation. In addition, this information may be used in checking the capacity of the apparatus proposed by various contractors, and may also be employed for determining the relative cost of heat and power purchased from outside parties, as compared with that generated upon the premises.

The first step in any case is to compute the maximum power required for all purposes, and from this the quantity of steam necessary to generate this power. Next determine the steam which must be furnished for heating, and by comparing this with the available exhaust from the engines, the necessary boiler power can be easily computed.

In the average building, power is required for lighting, elevator service, and in some cases for driving ventilating fans. Let us take these up in order and compute the weight of steam necessary for each, under average conditions.

The smaller offices and lavatories in a building of this kind are usually lighted with incandescent lamps of 16 candle-power each, while enclosed arcs or special incandescent lamps of higher power are used for stores, corridors, or other large areas. The final layout of the lighting scheme should, of course, be in charge of an experienced engineer, but for purposes of approximation, the following data will be found sufficiently accurate.

For general office illumination, where incandescent lamps are used, one candle-power is sufficient for each 3 or 4 sq. ft. of floor space. A 16-c.p. lamp, when new and on a 110-volt circuit, takes a current of about 0.5 ampere, and therefore has an efficiency of $.5 \times 110 \div 16 = 3.45$ watts per candle power. The efficiency of some of the more common incandescent lamps of higher power may be taken as follows: Meridian lamps, 2 watts per candle power; Nernst lamps, 1.8 watts; mercury-vapor lamps, 0.6 watts.

As it is very difficult to measure with accuracy the illuminating power of an arc lamp, it is customary to use the ampere or watt rating instead of expressing it in candle power as may be done in the case of incandescent lamps. For rooms lighted with arc lamps we may allow about 1.3 to 1.5 watts per square foot of floor space for stores, and 1 watt per square foot for corridors and hallways.

An example will make the use of the above data clear. An office building has 54,000 sq. ft. of floor space devoted to offices and toilet rooms, which are to be lighted with 16-c.p. incandescent lamps; 4,000 sq. ft. of floor space lighted with enclosed arc lamps; 8,000 sq. ft. of corridors lighted with Meridian lamps, and approximately 200 sq. ft. of space in the engine room and shop to be lighted with mercury-vapor lamps. Assuming 3 and 4 sq. ft. of floor space per candle-power in offices and corridors, respectively; 1.5 watts per square foot of space in the stores, and 1 watt per square foot in the engine room, what weight of steam will be required per hour if simple non-condensing engines are used, and what will be the required rating of engine and dynamo? $54,000 \div 3 = 18,000$ c.p. or $18,000 \times 3.45 = 62,100$ watts for offices and toilet rooms. $4,000 \times 1.5 = 6,000$

watts for stores. $8,000 \div 4 = 2,000$ c.p. or $2,000 \times 2 = 4,000$ watts for corridors. $200 \times 1 = 200$ watts for engine room. This makes a total of $62,100 + 6,000 + 4,000 + 200 = 72,300$ watts for lighting.

The next step is to determine the power of the engine and generator. The current required is 72.3 kw. or, in round numbers, 75 kw., which is the required capacity of the generator. As 1 horse-power is equivalent to 746 watts of electrical energy, we have $72,300 \div 746 = 97$ h.p. required at the lamp terminals. Assuming an efficiency of 75 per cent. for the engine and dynamo, including the loss in transmission, the indicated horse-power of the engine must be $97 \div 0.75 = 130$. The steam consumption of an engine depends upon its type, the pressure carried, the speed and point of cut off. Under average conditions with first-class engines of medium size, the following may be used.

Type of engine.	Pounds of steam per indicated horse-power per hour.	
	Non-condensing.	Condensing.
Simple, high-speed...	30-34	22-26
Compound, high-speed	24-28	18-22

Taking an average of 32 lb. for the present example, the quantity of steam required for lighting will be $130 \times 32 = 4,160$ lb. per hour.

The power necessary to operate an elevator depends upon its size, the method of construction and counter-balancing, the speed, and the efficiency. Placing these conditions in the form of an equation, we have $H.P. = S(W + w) \div 33,000 E$, where $H.P.$ is the required horse-power, W is the weight of live load, w is the unbalanced weight of car, S is the speed in feet per minute, and E is the efficiency. The live load for a passenger elevator is usually figured on a basis of 60 to 80 lb. per square foot of floor space, and the weight of the elevator itself from 100 to 125 lb. per square foot, which also includes the safety device.

The general method of computing the power is the same for both hydraulic and electric elevators, although they differ to some extent in detail, making it advisable to treat them separately.

In the case of hydraulic elevators it is customary to counter-balance them up to about three-fourths of the weight of the car. The speed varies from about 200 to 600 ft. per minute, 400 ft. being about the average for office buildings of medium size. The efficiency is about 60 per cent. In computing the weight of steam necessary to run the pumps it must be taken into consideration that all of the elevators will probably not be running at one time at their maximum capacity, and also that power is required only on the upward trip, as the weight of the car causes it to descend under the weight of a suitable braking device. When there is no definite information at hand, it is customary to compute the power necessary to run all of the elevators at one time under full load, and then base the steam consumption on two-thirds of the result.

Example: An office building has four elevators, each having a floor space of 30 sq. ft. What quantity of steam will be required by the pumps per hour, using the following average data: Live load, 70 lb. per square foot of floor space; weight of car, 100 lb. per square foot of floor space; speed, 400 ft. per minute; efficiency, 60 per cent. From the above we have: $W = 30 \times 70 \times 4 = 8,400$; $w = 30 \times 100 \times 4 \times .25 = 3,000$. Then for a continuous upward movement with a full load, the required horse-power would be $400(8,400 + 3,000) \div (0.6 \times 33,000) = 230$. Now under actual conditions, one-half of the time is devoted to the downward trips, and the power required is therefore one-half of the above or 115 h.p. Making allowance for stops, and for the time that part of the cars are idle, we may assume that it will be sufficient to provide for 70 per cent. of the above, or 81 h.p.

The steam consumption of pumps, such as are used for elevator service, may be taken as follows for average conditions: Simple, non-condensing, 120 lb. per horse-power-hour; compound, non-condensing, 65 lb.; triple, non-condensing, 40 lb. Assuming in the above example that compound pumps are to be used, the weight of steam required per hour will be $81 \times 65 = 5,265$ lb.

The most common types of electric elevators are the drum, screen, and duplex. The speeds at which these are commonly run may be taken as 350, 500, and 600 ft. per minute respectively, although for regular work speeds above 400 ft. per minute are usually found necessary for the average building. So far as the power is concerned, the drum and duplex types may be considered together. The efficiency of these machines runs from 50 to 70 per cent., although, theoretically, the former is the more efficient type. In practice it is not customary to count on much more than 50 per cent., which gives results on the side of safety. The method of balancing these elevators differs from the hydraulic, in that the entire weight of the car and from 40 to 50 per cent. of the maximum live load is counter-balanced. From this it is evident that with no load, the power required to pull the car down is that necessary to raise the counter-weight, which is equal to one-half the maximum live load, and to overcome the friction of the machine. When the car is half-full, it is balanced, and the power required is that due to friction only. At full load the conditions are the same as for an empty car, except the power is required during the upward trip instead of the downward. From the above it is evident that power may be required for both the upward and downward trips, depending upon the number of people in the car, but it will never be as great at any one time as in the case of the hydraulic elevator.

Example. What power will be required to operate two elevators of the drum type, each having a floor space of 6x7 ft. and running at a speed of 300 ft. per minute? The cars are over-balanced an amount equal to one-half the live load, and the machines have an efficiency of 50 per cent. In this case, w , the unbalanced weight of the car disappears, and the maximum live load is equal to only one-half the weight of the people in the car, the other half being counter-balanced, so that $W = 42 \times 70 \times 2 \times .5 = 2,940$ lb., from which the required horse-power = $2,940 \times 300 \div (0.5 \times 33,000) = 53$ h.p. If the full load was carried on both upward and downward trips, or sufficient of it on the downward trip to over-balance the counter-weight and the friction of the car, the conditions would be the same as in the case of the hydraulic elevator, that is, power would only be required on the upward trip. This condition, however, does not hold, especially in the case of office buildings, where during the morning hours the maximum loads are on the upward trips with empty or nearly empty cars coming down. Under these conditions the power is practically the same on both trips owing to the necessity of raising the counter-weight when the car is descending. This makes it necessary to treat the problem the same as though the machine were raising a continuous load. Assuming as before that a certain amount of time is required for passengers to enter and leave the cars, and that all of the cars will not be running at one time, we may take 70 per cent. of the above, or 37 h.p., as the maximum power to be delivered continuously by the motor. Assuming an efficiency of 80 per cent. for the motor and 75 per cent. for the generating set, the required indicated horse-power of the engine will be $37 \div (0.8 \times 0.75) = 61$. Knowing the type of engine to be used, the weight of steam per hour can be computed in the same manner as has already been explained for electric lighting.

The power required to operate duplex elevators

is practically the same, except a higher speed may be allowed.

The method of balancing a screw machine is practically the same as for the hydraulic type. The efficiency of this machine may be taken as about 70 per cent. The horse-power for driving elevators of this type is computed the same as for the hydraulic, except for the higher efficiency. After the power of the motor has been determined, the indicated horse-power of the engine and the weight of steam can be found as already described.

The ventilation in office buildings is usually confined to a limited number of rooms, such as lavatories, special offices, banking rooms, etc., although in some of the latest buildings erected practically all of the more important rooms have been supplied with fresh air. In computing the power of motors for this purpose we may assume a change of air once in 15 minutes in the rooms to be ventilated, and allow one horse-power for each 3,000 cu. ft. of air moved per minute. This is high for disk fans, with short connecting ducts and flues, but for general ventilating work it is a safe figure to use.

Example: An office building contains 480,000 cu. ft. of space which it is desired to ventilate by means of motor driven fans. What indicated horse-power must be provided at the engines for generating the necessary current?

$480,000 \div 4 \div 60 = 32,000$ cu. ft. of air per minute, and $32,000 \div 3,000 = 11$ h.-p. for driving the fan.

Assuming efficiencies of 80 and 75 per cent. for the motor and generating set respectively, the required indicated horse-power at the engine will be $11 \div (0.8 \times 0.75) = 20$ h.-p.

Having determined the amount of power required for all purposes and reduced it to pounds of steam, the next step is to compute the heat required for warming, ventilation, and hot-water service.

The heat loss from a building is due to the following causes: First, conduction of heat through walls and windows; second, leakage of warm air around doors and windows, and through the walls themselves; and third, heat required to warm the air for ventilation. The loss of heat through the walls of a building depends upon the material used, the thickness, the number of layers and the difference between the inside and outside temperatures. The leakage of air from a room varies from one to two or more changes of the entire contents per hour, depending upon the tightness of construction and the opening of doors, etc. It is common practice to allow for one change per hour in well constructed buildings where two walls of the room have an outside exposure. As the amount of leakage depends upon the extent of exposed wall and window surface, the simplest way of providing for this is to increase the total loss through walls and windows by a factor depending upon the tightness of the building construction. For brick buildings the heat loss in zero weather may be found approximately by multiplying the outside wall surface by 20, the glass surface by 85 and increasing the result 10 per cent. for leakage. For stone construction, multiply by 34 instead of 20. This gives the heat loss for southern exposures; for other exposures multiply the results as found above by the following factors:

Exposure. N. NE. E. SE. S. SW. W. NW.
Factor . . . 1.32 1.22 1.12 1.06 1 1.10 1.20 1.26

Example: A brick office building is exposed on the front and rear; it is 50 ft. in width and 150 ft. in height. The exposures are east and west, and the windows make up one-third of the total exposed surface. What will be the heat loss per hour in zero weather?

$(50 \div 50) \times 150 = 15,000$ sq. ft. total exposed surface. $15,000 \div 3 = 5,000$ sq. ft. glass surface. $15,000 - 5,000 = 10,000$ sq. ft. wall surface. $5,000 \times 85 = 425,000$ B.t.u. and $10,000 \times 20 = 200,000$ B.t.u., a total

of 625,000 B.t.u. $625,000 \times 1.10$ (for leakage) = 687,500, and $687,500 \times 1.16$ (for exposure) = 797,500 B.t.u. required for warming per hour.

The latent heat of evaporation of steam at 5 lb. pressure is 950 B.t.u., in round numbers; hence the weight of steam required per hour will be $797,500 \div 950 = 839$ lb.

The heat required for warming any given volume of air for ventilation may be found as follows: One heat unit will raise the temperature of one cubic foot of air 55° at average temperatures, or will raise 55 cu. ft. one degree. From this it is evident that the heat units required to raise the temperature of a given quantity of air through any number of degrees will be equal to the volume in cubic feet, multiplied by the rise of temperature in degrees, divided by 55.

Example: A building is to be provided with an air supply of 32,000 cu. ft. per minute. What quantity of heat will be required per hour to raise the temperature from zero to 70° ?

$32,000 \times 60 \times 70 \div 55 = 2,440,000$ B.t.u. in round numbers, and $2,440,000 \div 950 = 2,568$ lb. of steam. Assuming a temperature of 70° for the entering air, we may multiply the air volume supplied for ventilation by 1.1 for an outside temperature of 10° above zero, 1.3 for zero, and 1.5 for 10° below zero, which covers the conditions commonly met with in actual practice.

The heat required for hot-water service is easily computed as follows: One heat unit will raise the temperature of one pound of water one degree, and one gallon of water weighs approximately 8.3 lb., hence, the heat units required to raise any quantity of water through any given range of temperature, will be equal to the number of gallons times 8.3 times the degrees through which the water is to be raised.

Example: A building is to be provided with a hot-water supply for 100 gal. per hour. The average temperature of the water as it enters the building is 60° and it is desired to raise it to 170° , what weight of steam at 40 lb. pressure will be required per hour?

$100 \times 8.3 \times (170 - 60) = 91,300$ B.t.u. The latent heat of steam at 40 pounds pressure is 912; hence the weight of steam required is $91,300 \div 912 = 100$ lb.

After having determined the amount of steam required for all of the different purposes the next step is to compute the boiler power. Steam after having been used in an engine contains the greater part of its heat, and if not discharged into a condenser can usually be employed for heating purposes without affecting to any great extent the power of the engine. In general, we may assume for office buildings that it is a matter of economy to use the exhaust for heating, although various conditions must be considered in each case to determine to what extent this is true. The more important considerations bearing upon the problem are the relative quantities of steam required for power and for heating, the length of the heating season, the type of engine used and the pressure carried.

The first use to be made of the exhaust steam is the heating of the feed-water, as this effects a constant saving both summer and winter, and can be done without materially increasing the back pressure on the engine. Under ordinary conditions about one-sixth of the steam supplied to the engine can be used in this way, or more nearly one-fifth of the exhaust discharged from the engine.

We may assume in average practice that about 80 per cent. of the steam supplied to an engine is discharged in the form of steam at a lower pressure, the remaining 20 per cent. being partly converted into work and partly lost through cylinder condensation. The latent heat in a pound of steam at atmospheric pressure is 966; therefore, out of each pound of live steam furnished to the

engine there will be $966 \times .80 = 773$ B.t.u. available for heating purposes. It requires practically $210 - 50 = 160$ B.t.u. to raise one pound of feed-water from 50° to 210° ; and this is $160 \div 773$, or about one-fifth the available exhaust. Taking this into account, there remains for other heating purposes 64 per cent. of the entire quantity of steam supplied to the engine. When the quantity of steam required for heating is small compared with the total amount supplied to the engine, or where the heating season is very short, it is sometimes more economical to run the engine condensing and use live steam for heating. This can be determined in any particular case by computing the saving in fuel by the use of a condenser, taking into account the interest and depreciation on the first cost of the condensing apparatus, and the cost of water, if it must be purchased, and comparing it with the cost of heating with live steam. Usually, however, in the case of office buildings in northern latitudes it is advantageous to use the exhaust for heating, even if a condenser is installed for summer use only.

After having determined the amount of steam required for all of the different purposes, the next step is to compute the boiler power.

Example: Taking the case of the building alluded to in the previous examples, let us compute the required boiler power, assuming that hydraulic elevators are to be employed, and that exhaust steam is to be used for heating.

Referring back to the various illustrations in order, we have: Lighting, 4,160 lb. of steam per hour; elevators, 5,265 lb.; fan motors, 640 lb.; total, 10,065 lb.

$10,065 \times .64 = 6,441$ lb. available for heating purposes, exclusive of feed-water heating.

The weight of steam required for other purposes is as follows: Warming, 839 lb. per hour; ventilation, 2,568 lb.; hot water, 100 lb.; total, 3,507 lb.

From the above we see that the exhaust is more than sufficient for all heating purposes, so that it is only necessary to provide sufficient boiler power to supply the engines and elevator pumps, which amounts to 10,000 lb. of steam per hour. Assuming one boiler horse-power equivalent to the evaporation of 30 lb. of water per hour, the required capacity will be $10,000 \div 30 = 333$ boiler horse-power.

In a plant of this kind there should always be some reserve power for use in case of an accident or while cleaning or repairing one of the boilers. Some engineers provide a spare unit over and above that required under maximum conditions, which in the present case would probably amount to installing four 100 h.p. boilers. Another method would be to put in, say, three boilers of such power that any two could do the entire work by forcing them 30 per cent. beyond their rated capacity. The power of each unit in this case would be $333 \div (2 \times 1.3) = 128$, or a total of $128 \times 3 = 384$ h.p.

The power of the engines may be proportioned the same as the boilers, which by the latter method would call for three units each $(130 \times 20) \div (2 \times 1.3) = 58$ h.p., which in round numbers might be taken as 60 h.p. each.

The building might have a corner location and so be exposed on three sides instead of two, and also have less elevator capacity, so that the exhaust steam would have been less than that required for heating purposes instead of in excess. In this case the necessary boiler power would have been equal to that required for power, plus the difference between 64 per cent of this amount and the total amount required for heating purposes.

Having shown how to compute the power of boilers and generating sets, let us take up briefly some of the more important details in connection with the heating and ventilating arrangements.

The principal objection raised to the use of exhaust steam for heating has been the higher back pressure required on the engine, resulting in a loss of power nearly proportional to the ratio of the back pressure to the mean effective pressure. There are two ways of offsetting this loss; one by raising the initial or boiler pressure, and the other by increasing the cut-off of the engine.

Engines are usually designed to work most economically at a given cut-off, so that in most cases it is undesirable to change it to any extent. Raising the boiler pressure, on the other hand, is not so objectionable if the increase amounts to only a few pounds. Applying the latter method to the case of an engine having a clearance of 5 per cent., supplied with steam at 80 lb. pressure and cutting off at one-quarter stroke, we find that raising the back pressure 3 lb. calls for a corresponding increase of only 5 lb. in the boiler pressure, to maintain the same power at the engine. The indicator card shows a back pressure of about 2 lb. when an engine is exhausting into the atmosphere, so that an increase of 3 lb. would bring the pressure up to 5 lb., which should be more than ample to circulate the steam through any well designed heating system, even though it be of comparatively large size. A modern heating plant with ample mains and branches should circulate freely on a pressure not exceeding 2 lb., and good results are often obtained with one pound, or even less.

When a low-pressure heating system is combined with a high-pressure heating plant, the condensation must be returned to the boilers either by a return trap or pump.

As the exhaust steam is often insufficient to supply the entire heating system it must be supplemented by live steam taken directly from the boilers. This must first pass through a regulating valve in order to reduce the pressure to that carried on the heating system. An engine does not deliver steam continuously, but at regular intervals at the end of each stroke, and further, the amount will vary with the work done. When the work is light, very little steam will be admitted to the engine, and for this reason the supply available for heating will vary somewhat, depending upon the use made of the power. In mills the amount of exhaust steam is practically constant; in office buildings where the exhaust is obtained from a lighting plant the variation is greater, especially if power is also supplied for running elevators. In order to make the steam supply automatic, the system must be equipped with both a reducing valve and a relief or back pressure valve, the former for admitting live steam when the exhaust is not sufficient to maintain the required pressure, and the latter to allow the surplus to pass outwards when the quantity is greater than can be condensed in the heating system. Before entering the heating main the exhaust should pass through a good form of oil separator, so that the condensation may be returned to the boilers without injurious results.

Any of the usual systems of piping may be used in connection with exhaust steam heating, but great care should be taken that as little resistance as possible is introduced at bends and fittings, and the mains and branches should be of ample size. Usually the best results are obtained from the system in which the main steam pipe is carried directly to the top of the building, the distributing pipes run from that point, and the radiating surfaces supplied by a down-flowing current of steam.

In order to secure the benefit of a sealed return, a "false water-line," so called, should be established by the use of a water-line trap. This consists of a constant discharge float trap of large size mounted at such an elevation as may be necessary to produce the desired depth of water-seal. The return pipe should be brought into the

bottom of the trap instead of the top, as is usually the case, and a balance pipe for equalizing the pressure connected with the top. This pipe should be, if possible, not less than 15 or 20 ft. in length, and provided with a globe valve near its connection with the heating main.

When it is desired to remove the back pressure from the engines as far as possible, one of the so-called vacuum systems of heating may be employed. These are of two general classes; in one the radiators have two connections, but the usual hand valve on the return is replaced by a special automatic valve which opens when in contact with air or water and closes as soon as steam strikes it. The returns are gathered into a single main, and are connected with a vacuum pump, which delivers the condensation and air into a receiving tank where separation takes place, and from which the water is pumped back to the boilers. Short-circuiting through the various coils and radiators is prevented by the action of the automatic return valve, which causes each radiator to act independently of the others. In the second class of vacuum systems the air-valves are connected by piping with an ejector or exhauster which removes the air from the radiators, thus allowing the steam to flow in and take its place. The condensation in this case flows to the receiving tank by gravity the same as in the ordinary pressure system. The common expansion air-valves may be used on the radiators, although a special form

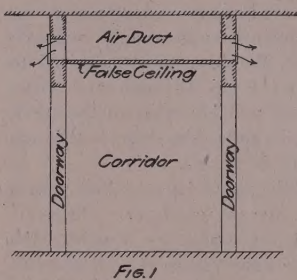


Fig. 1

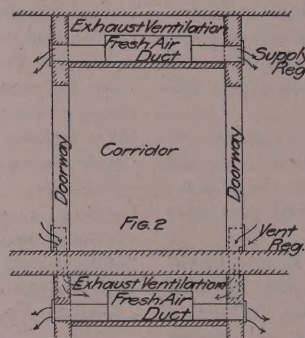


Fig. 2

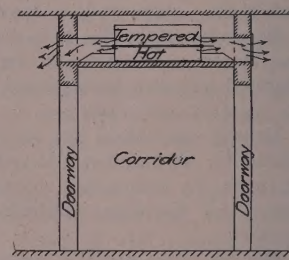


Fig. 3

designed with reference to the quick discharge of air is generally employed. The vacuum system has a large field of its own, and is of much value in cases calling for the special features which it possesses. In modern plants with pipes of ample size it seems preferable to rely upon the steam pressure, for forcing the air out of the radiators, and to allow the condensation to return to the receiving tank by gravity, rather than to install special mechanical means for accomplishing the same results.

When mechanical ventilation is applied to an office building the arrangement of the air-ways must be somewhat different from those of other buildings. Owing to their great height and the large number of small rooms which they contain, it is impossible to carry up separate flues from the basement. One of the best arrangements is to construct false ceilings in the corridor-ways on each floor, thus forming air-ducts which may receive their supply through one or more large uptakes extending from the basement to the top of the building. These corridor air-ways may be tapped over the door of each room, the openings being provided with suitable regulating dampers for gauging the air supply to each. Adjustable deflectors should be placed in the main air-shafts for proportioning the quantity of air to be delivered to each floor. Fig. 1 shows a section through a corridor where this method is used. If both supply and discharge ventilation are to be provided, the fresh air may be carried in galvanized iron ducts within the chambers, as shown in Fig. 2, and the remaining space used for conveying the exhausted air to uptakes leading to a discharge fan placed upon the roof of the building. In both of these cases it is assumed that heat is

supplied to the rooms by direct radiation, and that the air-supply is for ventilation only. This is the better arrangement on account of its simplicity, but if desired in special cases, the double-duct system may be used with mixing dampers back of the inlet registers, as shown in Fig. 3. When the double-duct system is used, the hot-air pipes should be thoroughly insulated to prevent excessive cooling of the air before reaching the rooms.

Book Notes.

The "Proceedings" of the Engineers' Society of Western Pennsylvania are among the most important journals published by American technical societies, and it is accordingly gratifying to have an excellent "Index" to them. The work has been done by Mr. Harrison W. Craver, of the Technology Department of the Carnegie Library of Pittsburg, which has published the pamphlet. The data were first compiled on cards for library use, but the demand for a printed index has led to the publication.

A handy appliance for adding series of numbers has lately been finding considerable favor among bookkeepers, auditors and engineers in the Pittsburg district. It is a piece of heavy cardboard, having narrow slots in its face, with small cardboard slides working vertically behind these slots. Above and alongside the slots are rows of numer-

als from 1 to 9, while on the slides are numerals from 1 through 9 to 0. The slides are moved up and down by any sharp pointed instrument, and the sum of the numbers is read off on a horizontal line of holes through which the numbers on the slides appear. The whole thing is bound in a durable cloth cover, and can be carried in the pocket. It is simple in construction and use, although hard to describe, and several months' trial of it in this office shows that it is very handy in adding numbers of more than three places. (The Dilworth Adder, Farmers' Bank Bldg., Pittsburg, \$1.00.)

A book which will probably be found useful by many public-service corporations and municipal works departments in small cities is "Quasi-Public Corporation Accounting and Management," by Mr. John F. J. Mulhall. It is essentially a description of the general books which are employed by all classes of incorporated companies, and those special systems of accounting used by water-works, gas works, electric light works, steam heating works, telephone companies and electric railway companies. In the preparation of the data the author had the assistance of Mr. William Wheeler in the portion relating to water-works, of Mr. Albert F. Davol in that relating to telephone companies, of Mr. William F. Goepper in that relating to electric light works, and of Mr. James H. Neal in that relating to electric railways. The books of such companies are radically different from those of ordinary business corporations, and it is not unlikely that some of the accounting muddles which quasi-public companies have suffered have been due in a considerable measure to attempts to force the usual book-

keeping methods upon them. Local conditions may call for special methods of keeping some accounts, yet the general suggestions and the forms given in the book, which have stood the test of trial, will doubtless prove of use to those starting new companies as well as to old companies which find their systems cumbersome or inaccurate. (Boston, Corporation Publishing Co., P. O. Box 2428.)

It is not often that an experienced designer of any class of machinery feels willing to explain step by step the details of such work, and for this reason Mr. H. M. Hobart's "Elementary Principles of Continuous-Current Dynamo Design" must be ranked as a rather unusual as well as very good book. In it the author explains the various steps taken in designing eighteen different machines, and after the student has made all the computations these require he should be pretty well grounded in the procedure. It is of course impossible to teach all features of the subject in a textbook; shop methods, the prices paid for materials and labor and the quality of both of the latter items of expense have to be taken into consideration by a chief draftsman and are capable of being judged accurately only by somebody with experience. The plan of the book does not include such subjects, however, although it contains a large amount of data which will be found useful in the everyday work of the drafting room. The reader begins with the calculations for the electric conducting circuit of the eighteen dynamos, then proceeds to the magnetic circuit; armature interference and the design of field coil windings are next taken up, and then comes a discussion of the proportioning of continuous-current dynamos, the voltage between segments and the reactance voltage. One of the most useful chapters in the book to the student is on dynamo design coefficients, which, with a study of good machines, will furnish a very creditable amount of information on which to claim an acquaintance with the general subject. (New York, Macmillan Co., \$3.00.)

The commercial value of geological surveys is well shown in a report on "Building and Ornamental Stones of North Carolina" recently issued by the Geological and Economical Survey of that State. It is pretty well known among Eastern architects and builders that North Carolina possesses building stones of excellent quality, which will undoubtedly be developed to a far greater extent than at present as soon as facilities for shipment are improved. Even a casual examination of this report will show how important are the granites, gneisses and associated crystalline silicious rocks of the State. The standard grades of architectural stone are abundant and there are some beds of unique varieties, like the beautiful unakite, composed of yellow-green epidote, dull pink or red feldspar and quartz. The marbles, limestones, serpentines and verdantique marbles are described in a similar manner to the granite group, and attention is called to a locality where a pure white marble of fine texture, suitable for the best grades of cut work, has recently been found. The sandstones and quartzites are next taken up, and it is stated, contrary to general belief, that there are some beds of these stones in the State which can be developed for building material owing to their freedom from the joints which greatly reduce the value of most sandstones in this part of the country. Attention is also called in the report to special monumental stones, such as the leopardite of Mecklenburg county and the orbicular-gabbro diorite of Davis county. The report describes these various classes of rocks in such a way as to make the information of most service to the architect and builder. The general character of the stone in each group found within the State is first stated broadly. The beds of each county are described when they are of economic importance, and there are full notes concerning

each quarry that is being worked. The mineral composition of the stones is stated, and the effect of dikes and veins on the quarries is explained. The methods of quarrying and working stone are outlined. A special chapter brings together all the information concerning the weathering of North Carolina building stones which has been collected; there are some excellent tables giving the results of tests made on material from various localities in the State. (Chapel Hill, N. C., State Geologist; 25 cents in paper, 50 cents in cloth.)

More than twenty-five years ago Mr. Theodore Cooper prepared his first railroad bridge specifications. From time to time they have been revised as railway conditions and the progress in bridge building demanded, until to-day his "General Specifications for Steel Railroad Bridges and Viaducts" are the best known specifications of their class. The tenth revision of them has just appeared, with changes in 45 clauses and a new table giving the weights of recent heavy passenger and freight engines. The specifications themselves are too well known to need comment, but the author's note concerning them is of interest; it reads as follows: "Specifications have no executive functions. Unless intelligently supervised and executed they have little value. The author's experience forces him to the conclusion that plans and structures fully complying with the specifications are limited in number; many are defective in important details. We are now at a period when railroads will demand bridges capable of carrying the maximum possible train loadings, not only safely, but rigidly. There will be hereafter no increasing train loads to cover or excuse the faults of design, details of construction or inferior material. Bridges of the future must be relatively better than those of the past. Any false economy by scripping the details or using an inferior class of material will not redound to the credit of the bridge engineer." The pamphlet is sold at 50 cents by Engineering News Publishing Co., New York, which also sells at the same price the "General Specifications for Steel Railroad Bridges and Structures," prepared under the direction of Mr. Virgil G. Bogue by Mr. Albert W. Buel. During the last three years a considerable tonnage of railroad and highway bridges and railroad structures has been built under practically the same requirements. The results were so satisfactory and free from the misunderstandings and special interpretations which often attend this class of work that the specifications have been generalized. The quality of material required in them is first-class, but such as can be readily obtained in any American mill without extra cost. A choice is offered between three grades of workmanship for railroad bridges, and in a section of the pamphlet on highway bridges the requirements for workmanship are still further modified. A new uniform live load is given which may be substituted for the Cooper concentrated loadings by engineers who prefer to use uniform loads rather than wheel loads in their computations. It will give somewhat greater moments for spans up to about 150 ft. and slightly smaller moments for spans over 400 ft. Mr. Buel makes no claim for originality in the specifications and publishes them in the belief that their clearness, wide range of application and number of points covered will fully compensate for their length.

A little book on the "Economics of Railroad Location," which Mr. Walter Loring Webb has recently written, fills in a considerable measure a widespread demand for a reliable explanation of the basic principles which should govern the work of the constructing and operating engineer. This demand is not only from young men entering railway service, but also from the large group of intelligent investors in railway securities who desire to know something about the various departments of the business in which their earnings are

employed. The ponderous work on the subject, which was written by the late A. M. Wellington, has long been misleading, not only on account of its obsolete data, but also owing to the many views of its author, which the test of time has shown to be erroneous. This is not meant to imply that everything in Mr. Webb's book is likely to win the approval of all readers, for there are many disputed features of railway economics and no discussion of the subject can agree with the views of everybody. In fact the first part of this volume, relating to the broad financial and legal features of railway affairs, relates very largely to controversial subjects, which concern only indirectly the economics of railroad construction. Theoretically transportation facilities will be profitable for those giving them wherever there is enough traffic; theoretically it is good public policy to encourage, by liberal franchises, land grants and financial assistance from public funds the construction of roads which will develop sections of the country where improvements are possible; practically the ways in which public interests are neglected in granting these privileges are many. Stupid legislation and laws passed for blackmailing purposes have led to acts by railroads as illegal as the laws they broke were unjust, and in addition the directors of railroad companies and the politicians of the mercenary class have produced on a large scale all the disagreeable features which attend any kind of business competition where some of the parties are unable or unwilling to work for anything but immediate profits. In the second part of the book the author takes up the operating features of railway affairs. He divides operating expenses into charges for maintenance of way and structures and those for conducting transportation, a classification that is now general on account of the statistical requirements of the Interstate Commerce Commission, whose reports furnish the data used by him in explaining the relative importance of the various items. The next five chapters, on motive power, car construction, track construction, train resistance and momentum grades, point out in much greater detail those features of their respective subjects which affect operating expenses. In the third part, on the physical elements of railway lines, there are discussions of the effect of distance on operating expenses and receipts, curvature, minor grades, ruling grades, pusher grades, and balancing grades for unequal traffic. In both the second and third parts there are numerous points mentioned on which there is a decided difference of opinion, and in most cases the author has taken pains to indicate this fact and give the reasons for his beliefs. One example of this will suffice: "Many locating engineers have started out to locate a line with instructions that their maximum rate of curvature should not exceed 6 deg. . . . It is far better to operate a road on a 10-deg. or 15-deg. curve in some one place, provided the cost of avoiding such a curve will be very large. . . . The engineer should not give undue prominence to curvature in comparison with the other features of alignment, which are really of far greater importance. He should remember that so far as the cost of trackwork is concerned, there is little if any saving in this respect, and that the extra cost of operating trains on curves is very nearly independent of the radius of curvature. Of course the trains cannot be operated at high speed on sharp curves, but if the road is a minor road such a condition will have almost no effect on the operation of trains. Above all, the engineer should not waste the capital of the road, which is usually limited, in an effort to avoid curvature, when any spare funds may more profitably be expended in making reductions of grade which will be of vastly greater financial value." The book as a whole is a clear and reliable discussion of an important branch of railway affairs. (New York, John Wiley & Sons, \$2.50.)

Letters to the Editor.

FORMULAS FOR REINFORCED CONCRETE BEAMS.

SIR:—The writer submits for discussion the following formulas for reinforced concrete beams: Let the variation in compression in concrete be measured by a straight line.

Let w = width of beam.

" d = depth from top of beam to center of steel.

" x = depth from top of beam to neutral axis.

" $d - (x \div 3)$ = resisting arm of the beam.

" r = ratio of elasticity between steel and concrete.

" u = ultimate compressive strength per square inch in concrete.

" p = mean pressure per square inch in concrete in compression.

" $2p$ = pressure on extreme fiber of concrete.

" t = tension per square inch in steel.

" a = area of steel in square inches.

" p/t = percentage of steel in terms of concrete above neutral axis.

" m = resisting moment of beam.

From the above it can be shown that

$$m = pwx (d - x/3) \quad (1)$$

$$d = \frac{3m + pwx^2}{3pwx} \quad (2)$$

$$w = \frac{m}{px (d - x/3)} \quad (3)$$

$$a = \frac{m}{(d - x/3) t} \quad (4)$$

$$x = \frac{2p r d}{2p r + t} \quad (5)$$

The value of x is derived from the equation $(d - x) \div r = t \div 2pr$.

Before designing a beam, values for r , p and t must be fixed, from which the value of x in equation (5) may be found in terms of d and substituted in equations (1), (2), (3) and (4). A value for w may then be assumed and the value of d found, or, vice versa. The ratio between w and d should, of course, be adjusted, if necessary, to secure economy in material.

For 1:2:4 concrete, let $r = 10$; $u = 2,400$; $p = 300$; $2p = 600$; $t = 12,000$, and $p/t = 2.5$ per cent. Then from the general formulas (1), (2), (3),

$$m = 88d^2w \quad (6)$$

$$d = \sqrt{m \div 88w} \quad (7)$$

$$w = m \div 88d^2 \quad (8)$$

For 1:2½:5 concrete, let $r = 12$, $u = 2,000$, $p = 250$, $2p = 500$, $t = 12,000$, and $p/t = 2.08$ per cent.

Then, as above:

$$m = 73d^2w \quad (9)$$

$$d = \sqrt{m \div 73w} \quad (10)$$

$$w = m \div 73d^2 \quad (11)$$

For 1:3:6 concrete, let $r = 15$, $u = 1,600$, $p = 200$, $2p = 400$, $t = 12,000$, and $p/t = 1.67$ per cent. Then, as above:

$$m = 59d^2w \quad (12)$$

$$d = \sqrt{m \div 59w} \quad (13)$$

$$w = m \div 59d^2 \quad (14)$$

If $t = 16,000$, then, in 1:2:4 concrete:

$$m = 74d^2w \quad (15)$$

$$d = \sqrt{m \div 74w} \quad (16)$$

$$w = m \div 74d^2 \quad (17)$$

And in 1:2½:5 concrete:

$$m = 61d^2w \quad (18)$$

$$d = \sqrt{m \div 61w} \quad (19)$$

$$w = m \div 61d^2 \quad (20)$$

And in 1:3:6 concrete:

$$m = 49d^2w \quad (21)$$

$$d = \sqrt{m \div 49w} \quad (22)$$

$$w = m \div 49d^2 \quad (23)$$

And $p/t = 1.875$ per cent., 1.56 per cent. and 1.25 per cent., respectively.

$a = m \div t (d - x/3)$ will be found equal to the area of concrete in compression multiplied by p/t .

In the matter of reinforcement against shear, the writer is of the opinion that it is sufficient to space vertical stirrups at distances apart equal to $d - x/3$, beginning at the center and running to each end, each stirrup being dimensioned to resist 50 per cent. of the total shear at its position, with an arbitrary minimum size of stirrup.

This assumes that the shearing strength of concrete will take care of one-half of the shear, and, inasmuch as beams without shear reinforcement are more than half as strong as those having it, this seems a safe assumption.

There is, of course, no need of shear reinforcement at the center of the beam, but it is the opinion of the writer that stirrups there will add materially to the crushing resistance, which is greatest at that point, and, to act most effectively in that way, the stirrups should be in the form of an inverted "u" with the ends wrapped tightly around the horizontal reinforcement.

The writer does not claim that the ratios of 10, 12 and 15 for 1:2:4, 1:2½:5, and 1:3:6 concrete, and ultimate strengths of 2,400, 2,000 and 1,600, respectively, are correct generally. These values will vary, depending on the quality of the materials and workmanship; but, for good average concretes, they are probably approximately correct on the safe side. The factor of 4 for working stresses will probably be accepted as sufficient.

The writer would be glad to see a discussion by your readers of these assumed values which so materially affect the proportions of reinforced concrete.

For example, if $t = 12,000$, $r = 15$, and $p = 300$, $d = \sqrt{m \div 111w}$; while if $t = 16,000$, $r = 10$, and $p = 300$, $d = \sqrt{m \div 74w}$.

Assuming $m = 400,000$ and $w = 12$, $d = 17.33$, or 21.22, depending on the values of t , r and p above.

As to relative economy between $t = 12,000$ and $t = 16,000$, with $r = 10$ and $p = 300$, the first value of t will give $d = 19.46$ and the second 21.22, and the area of steel will be $a = 1.93$, or 1.29, respectively.

Figuring concrete at 25 cents per cu. ft., steel at 4 cents per pound and lumber at 3 cents per foot B.M., the beam with $t = 16,000$ would cost 1½ cents per foot less than the beam with $t = 12,000$. This being the case, $t = 12,000$ should be chosen, since the lower stress on the steel would keep the neutral axis lower and permit the use of plain round bars and probably a lower priced steel, in which case it is altogether probable that the cost would also be in favor of $t = 12,000$.

Yours truly,

El Paso, Nov. 19.

J. L. CAMPBELL.

PLANE TABLE SURVEYS.

SIR: Two years or so ago you published an article on the use of the plane table in railway surveys made in Indiana and Illinois, and on the strength of that information I bought an outfit for use down here. At the time it arrived we were pretty busy and at once put the table in service, with a good transitman in charge. After working with it for a week he told me he would have to resign, as he could not retain his self-respect and continue to train with a thing he characterized by blistering terms. So the plane table was carefully packed away in its box and stored in my office. I made up my mind that the instrument might be of some service in the hands of people who did nothing but plane table work,

but it would not do where it was necessary to take on and lay off men so frequently that only the nucleus of a good crew could be permanently engaged.

This opinion has been strengthened by our experience this season. Our firm was engaged to make some surveys for railroad interests which desired to keep their names unknown. The country was mainly rolling prairie, but it was cut up by creeks in places in a manner that made topography at such points rather tedious. At the request of an Eastern friend, we had along a young fellow who was sent out to recuperate from a too rapid pace during the previous winter; he had studied surveying in some high school or academy and is a mighty bright chap, who can do things, when he gets his pace, far beyond the capabilities of us surveyors. He was sent up to the office one day after supplies, and when he came back he had the plane table along with him. Naturally we all laughed at him for thinking he could do anything with an instrument that had floored one of the best transimen living, but he soon showed us that we had been running it on the wrong plan. This fellow was a remarkably quick draftsman, and after about a week's practice he could cover ground as quickly as one of our old parties, while before a month was up he had us all beaten to a finish.

After watching him a good many times I became convinced that we had started in wrong with our first trial of the table, and I am sending you this note so that others may not make the same mistake. The instrument was of the type described by Mr. Wilson in a paper before the American Society of Civil Engineers a number of years ago; in fact I bought it through a Geological Survey engineer. It was used by the first man who tried it just as he had been accustomed to use a transit, and he fussed over every sight he took until he made himself and all who saw him extremely irritable. The young man worked in an entirely different way, so I am told, when he started in. He kept cool in the shade of a tree near camp and had a boy running around a day or so while he got the hang of the thing so that he felt at home with the telescope and could plot the lines quickly and accurately. Not being trained by years of experience with a transit and level to take shots in a certain way, he adapted himself to the alidade far more quickly than an old surveyor could, while his ability as a draftsman made it second nature for him to do the plotting. It is well known that many instrument-men are very slow and inaccurate draftsmen, and the plane table in their hands is bound to be a failure.

We have only one plane table in our office and this young man used it until the season's work was finished, so I have not had a chance to learn how well another novice could take it up. It is my intention, however, to put it in charge next year of one of our field draftsmen who has shown some ability to think for himself, and I expect to secure good results from it. I am sure, however, that any attempt to secure rapid work with the instrument in the hands of an experienced transitman will prove a failure unless he is given plenty of time to become familiar with it and is naturally a quick and accurate draftsman.

The work done with the instrument this season has all been tied to regular transit and level lines, and the errors in it have been under 0.25 ft. per mile in elevation and 40 ft. in distance. The country was favorable for the work, as a rule, as the rodman was able to do all the clearing required without much loss of time. I did not pay much attention to the details of the work, and so cannot say just what methods were followed under all conditions, but the cost and quality of the results left nothing to be desired.

LOCATING ENGINEER.

Kansas City, Nov. 17.